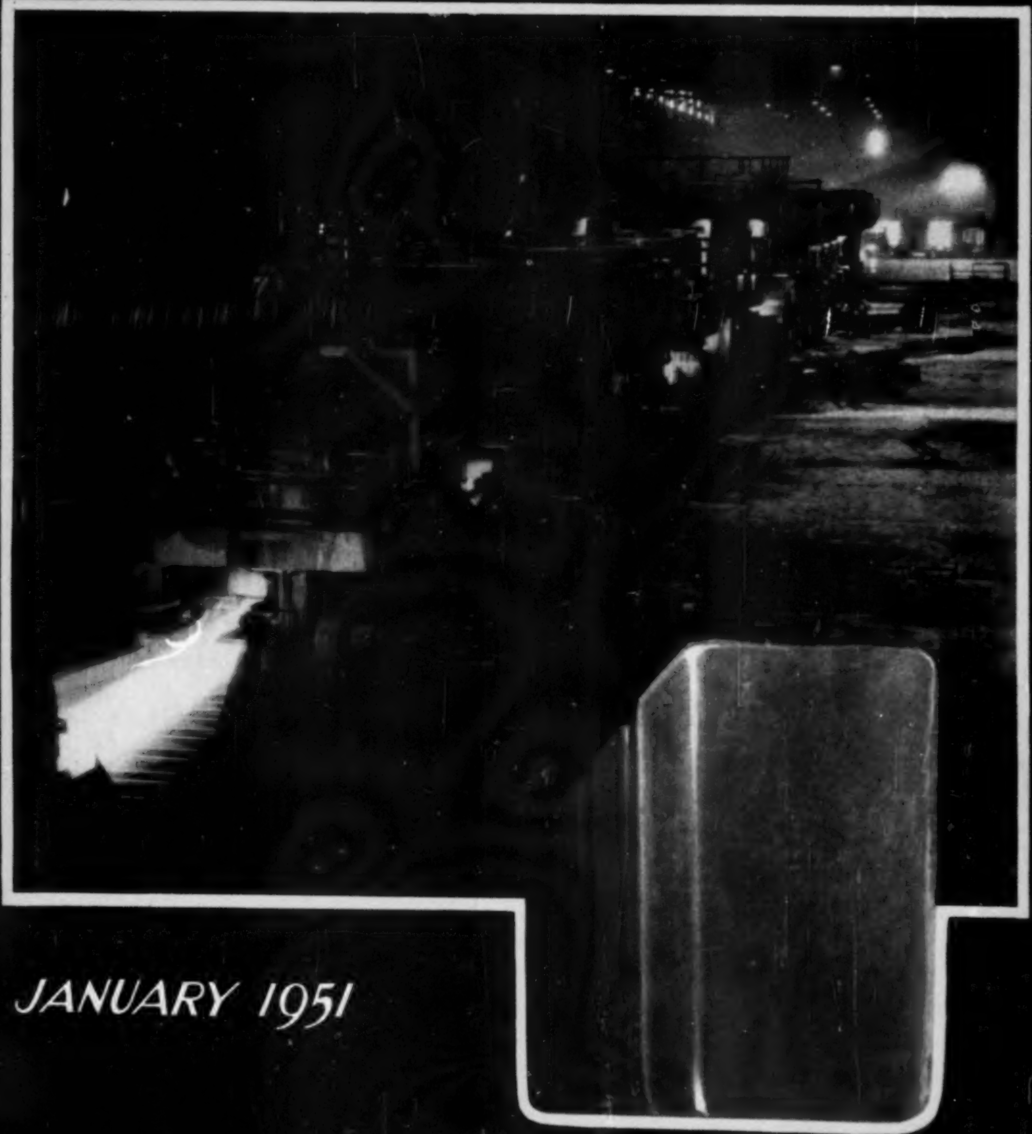
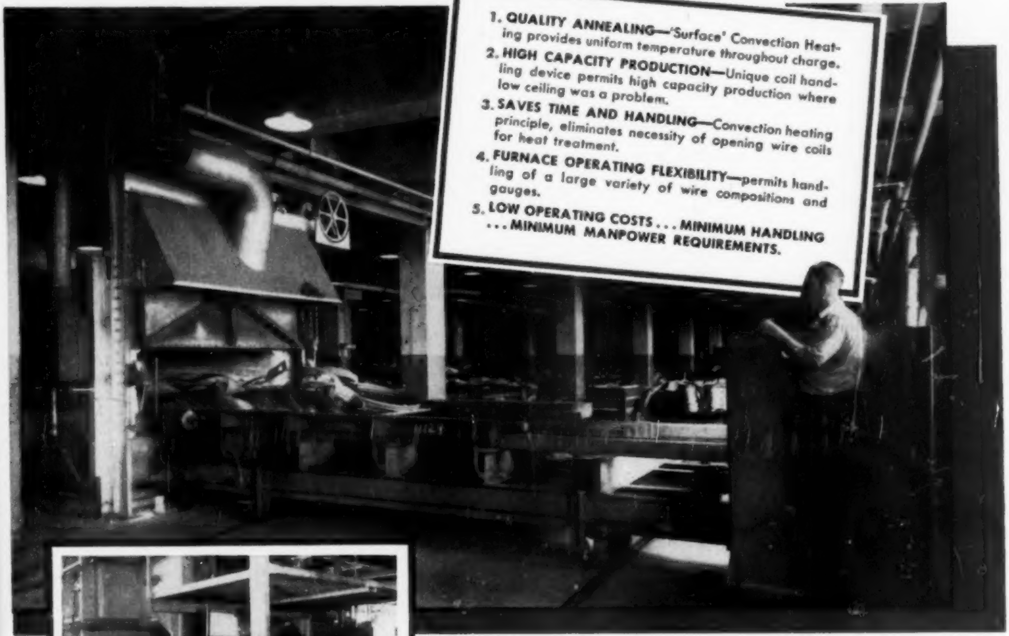
METAL PROGRESS



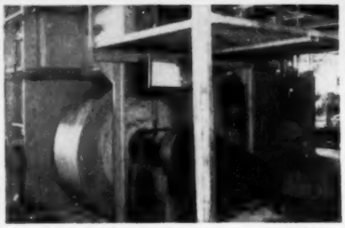
JANUARY 1951

'Surface' WIRE ANNEALING FURNACE

. . . meets unusual production requirements



1. **QUALITY ANNEALING**—'Surface' Convection Heating provides uniform temperature throughout charge.
2. **HIGH CAPACITY PRODUCTION**—Unique coil handling device permits high capacity production where low ceiling was a problem.
3. **SAVES TIME AND HANDLING**—Convection heating principle, eliminates necessity of opening wire coils for heat treatment.
4. **FURNACE OPERATING FLEXIBILITY**—permits handling of a large variety of wire compositions and gauges.
5. **LOW OPERATING COSTS . . . MINIMUM HANDLING . . . MINIMUM MANPOWER REQUIREMENTS.**



Rear view of 'Surface' Annealing Furnace showing high speed—high capacity recirculating fan used for convection heating. This assures maximum speed and uniformity of heating.

The many 'Surface' Heating Installations, whether convection heating, direct-fired or controlled atmosphere, have proved their economy in operation.

Quality heat treating, at a production rate to keep pace with high volume drawing operations, was made possible in this low-ceiling building with the use of the highly-efficient 'Surface' Convection Furnace shown above. This furnace is equipped with a unique materials handling mechanism. Non-ferrous wire coils are sling-loaded on to an alloy charging tray which is moved in and out of the furnace on roller rails.

Non-ferrous wire is heat treated at rates of 2500 lbs. net, and upwards per hour. Temperature range up to 1250°F.

This is a typical example where 'Surface' personnel worked in cooperation with company management and engineers to design heat treating equipment in keeping with plant production needs. If you have a special heat treating problem for non-ferrous or ferrous materials, for any required temperatures, it will pay you to discuss it with a 'Surface' representative. No obligation.

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

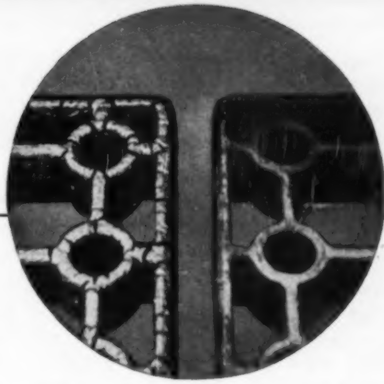
Stein & Roubaix, Paris *FOREIGN AFFILIATES:* *British Furnaces, Ltd., Chesterfield*

'Surface' INDUSTRIAL FURNACES

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging. Gas Atmosphere Generators.

ONCE THEY WERE TWINS

. . . but see the difference after 10 months' service!



THIS CLOSE-UP shows cracked condition of standard 35% Ni.—15% Cr. analysis tray on left . . . compared to THERMALLOY* "58B" tray on right. Both were in identical service for a 10-month period. THERMALLOY "58B" was recommended by Electro-Alloys engineers to improve service life for this application.

The heat treat trays shown above were part of an order supplied to a large automotive manufacturer by Electro-Alloys. *On the left* is a tray of standard analysis (35% Ni.—15% Cr.) which had been specified and used by the customer for some time. *On the right* is a tray of special analysis—THERMALLOY "58B"—recommended by our metallurgists after a careful study of the job requirements.

At our suggestion, a split order was placed on a trial basis. The pictures, taken after 10 months in carburizing service followed by an oil quench, tell their own story. Standard trays (left) had failed completely. They were badly checked and showed "growth" of as much as ⅜ of an inch on one dimension. Trays of THERMALLOY "58B" (right)—with exactly the same amount and kind of service—barely showed signs of use. There was no checking or cracking and "growth" was scarcely measurable.

Here's proof that expert metallurgical knowledge *can* make a substantial difference in the life of heat treat parts. To put such knowledge to work for you, just phone your nearest Electro-Alloys office, or write Electro-Alloys Division, 2091 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN **Brake Shoe** COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

We are Specialists in

BIG CASTINGS

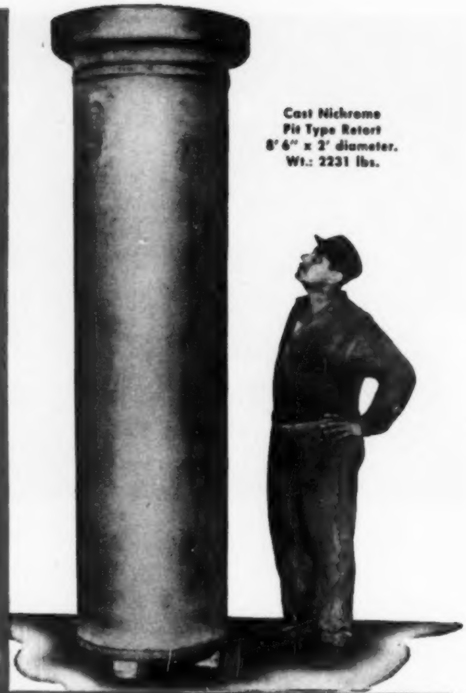
for the Heat-Treating Field

The efficiency and reliability of Driver-Harris casting procedures are in evidence in hundreds of plants thru-out the country, where retorts of cast Nichrome* and Chromax*—ranging up to 5000 pounds in weight—are giving dependable service day in and day out.

Our advanced welding techniques enable us to produce high performance muffles of virtually any length desired. For example, Nichrome muffles almost 70 feet in length, composed of cast sections welded together, are performing as effectively as conventional size units cast in one piece. And our shaker hearth muffles, with bottom plate machined to specifications and top plate welded in position, are giving outstanding service over remarkably long periods of operation.

The comparatively high rate of heat transfer of thin-walled Nichrome and Chromax, resulting in shorter cycles, helps speed up production. The reduction in weight made possible by these exceptional alloys, coupled with their *high heat and corrosion-resistant qualities,* results in appreciably lower heat-hour costs.

And heat-hour costs are the primary consideration. Heat-treating equipment that proves *most economical in the long run*—by delivering more hours of efficient, trouble-free performance—is the *most economical to purchase initially.* For this reason, it will profit you to consult with us. We not only can put the highest grade nickel-chromium alloys at your disposal, but—with over 40 years of practical foundry experience to our credit—can give you sound and valuable assistance.



Cast Nichrome
Pit Type Retort
8' 6" x 2' diameter.
Wt.: 2231 lbs.

New Model Cast Nichrome Rotary
Carburizing Retort. Wt.: 600 lbs.

Fabricated Cast Nichrome
Shaker Hearth Muffle. Wt.: 595 lbs.

Photos courtesy of American Gas Furnace Co.

FIFTIETH ANNIVERSARY

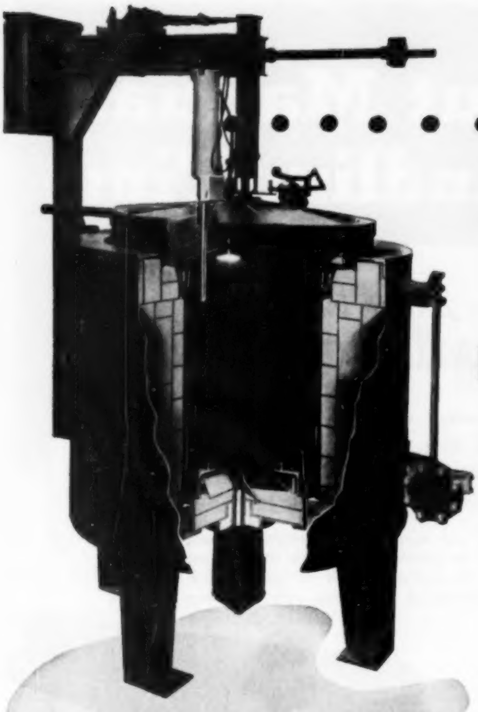
Nichrome and Chromax are manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. Reg. U. S. Pat. Off.



Microcarb Control is part of the Series H Homocarb furnace. This new furnace with its many important features . . . solid bottom retort, convection cooler, new fan housing and work support, aerodynamically designed vanes and discharge jets . . . is a superior heat treating tool.

Homocarb Furnaces Feature Microcarb AUTOMATIC Atmosphere Control

NOW heat treaters can do what formerly has been impossible . . . that is, continuously measure and control the carbon potential of a furnace atmosphere directly in terms of per cent carbon.

A new development by Leeds & Northrup Company, called "Microcarb" Control, makes this possible. It regulates atmospheric carbon content during heat treating as accurately as temperature is regulated. Atmosphere can be adjusted to increase or decrease the carbon potential automatically, as required for the job . . . whether it's surface carburizing, homogeneous carburizing, carbon restoration, hardening or annealing.

Principal feature of the Microcarb carbon control system is its Carbohm detecting element. This device projects into the furnace work chamber like a thermocouple; electrically senses the carbon potential of the furnace atmosphere. Connected to the element is a Microcarb Controller, which automatically adjusts the flow of Homocarb fluid to hold carbon potential of furnace gas at any selected value between 0.15 and 1.15 per cent carbon. For the heat treater's guidance, a Micromax recorder draws a continuous record of per cent of carbon as detected by the Carbohm element.

Microcarb Control is supplied for use with Leeds & Northrup Homocarb furnaces. It can be ordered as an integral part of new Homocarb equipments, or can be added to certain furnaces now in service.

For further information write to our nearest office or to Leeds & Northrup Company, 4927 Stenton Avenue, Philadelphia 44, Pennsylvania.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad T-620(31)

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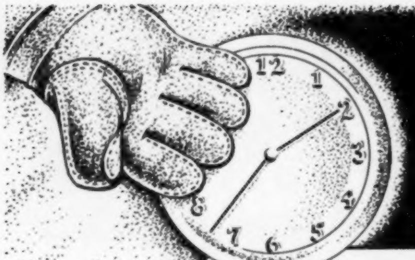
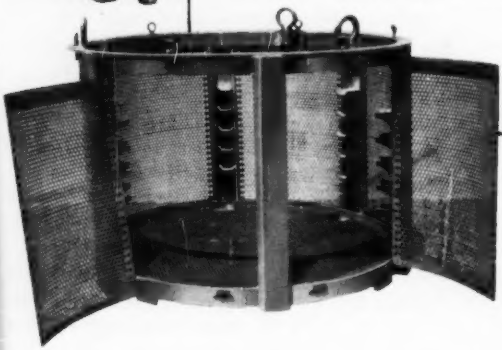


Cut Manual Handling Time

WITH *Light Weight* PSC ANNEALING CONTAINERS

Because they weigh up to 2/3 less than cast containers, PSC welded alloy annealing units obviously handle much easier and faster. Let us show you how installations are effecting impressive savings in labor costs alone.

Left top, light-weight box with sand seal construction for bright annealing.
Left bottom, special basket for aircraft parts; movable sides and trays.
Right top, annealing tubes for steel mills. Only ¼" alloy; years of service.
Right bottom, combination annealing and pickling rack. Top braces removable.



In addition to the savings in handling time, PSC light-weight annealing containers effect four other substantial economies. First, being so much lighter in weight, they attain pot heat in less time; PSC installations have shortened heating cycles as much as 5 hours. Second, fuel savings; a recent study showed a $40 saving per anneal. Third, being less bulky, PSC units increase furnace capacity. Fourth, their much longer service life cuts replacement costs.

Standard and Special Types for Every Purpose

PSC welded alloy heat-treating equipment is furnished in any size, design or metal specification: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc. As a pioneer of welded alloy units, we offer a wealth of experienced engineering assistance. Send blue prints or write as to your needs.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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You will want all the facts about the new low cost Olsen Super "L" Testing Machine with SelecΦrange Indicating System*

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*Patents Pending.

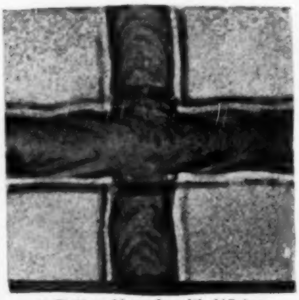
CORROSION RESISTANCE *Without* COLUMBIUM

If you have had difficulty in obtaining columbium stabilized welding electrodes such as Type 347, you'll find Arcaloy ELC (extra low carbon) electrodes a suitable alternate. Service tests have proven these electrodes equal to stabilized grades and far in excess of ordinary grades.

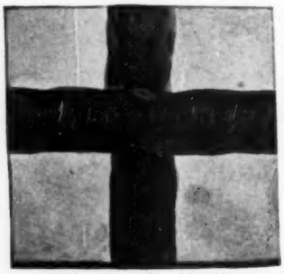
5 YEARS DEVELOPMENT - 2 YEARS IN SERVICE

As the leading manufacturer of stainless steel welding electrodes, Alloy Rods Company went to work on the problem of eliminating the necessity of Columbium in arc welding as early as December 1945.

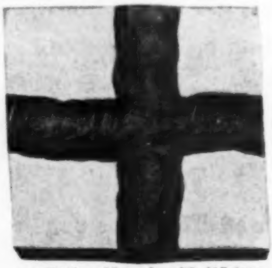
Since June 1948, Arcaloy Type 308 ELC (Extra Low Carbon) and Arcaloy Type 316 ELC Electrodes have been used on many weldments in various industries and have proven satisfactory under service conditions.



• Butt weld made with ½" type 304 plate and welded with type 308 electrodes. NOTE dark bands of corrosion due to carbide precipitation in heat affected zones.



• Butt weld made with ½" type 347 plate and welded with type 347 electrodes. NOTE absence of corrosion in heat affected zones, when Columbium stabilized plate and electrodes are used.



• Butt weld made with ½" type 304 ELC plate and welded with 308 ELC electrodes. NOTE absence of corrosion in heat affected zones, when ELC plate and ELC electrodes are used. Compare with type 347 weld (center.)

• Actual size — as welded. Etched 12 hours in 10% nitric — 3% hydrofluoric acid solution at 175° F. Photographs courtesy ARMCO Steel Corp.

CARBON CONTENT IMPORTANT

Arcaloy Types 308 ELC and 316 ELC (Extra Low Carbon) electrodes produce weld deposits containing .03% maximum carbon. In order to achieve complete immunity to inter-granular carbide precipitation in unstablized austenitic alloys, carbon content must be reduced to less than .02%. However, it has been determined that *material containing .03% maximum carbon content will possess sufficient immunity* to safely withstand temperatures in the carbide precipitation range for reasonable periods of time.

ARCALOY 308 ELC and 316 ELC

Arcaloy Type 308 ELC electrodes will weld stainless types 321 (titanium stabilized) and 304 ELC without appreciable carbide precipitation. Arcaloy Type 316 ELC electrodes will weld stainless Type 316 stabilized and 316 ELC plate without appreciable carbide precipitation.

Get all the facts on these new Arcaloy electrodes by writing for a copy of "Arc Welding Stainless Steel Without Columbium."

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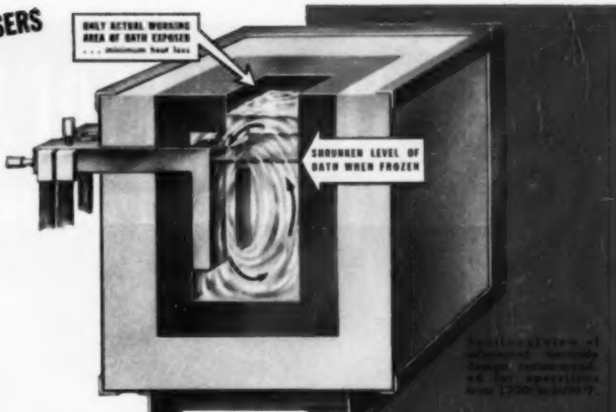
THE QUALITY LINE IN THE

STEEL CONTAINER

Moisture, dirt and grease proof. Easy to stock.



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Threadwell Tap & Die Company
[illegible] Drill Company
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Westinghouse [illegible]
... and dozens of others

THE Preferred Practice

FOR HARDENING TOOLS AND DIES

(High Speed, High Carbon-High Chromium, Stainless and Carbon Steels)

*W*hen such an imposing array of the world's leading makers of high speed tools and dies adopt the same heat treating method and equipment, you can count on it that there's a reason—several reasons in fact.

Productive capacity is two or three times that of other heat treating methods because of faster heating.

Distortion is negligible.

Surface protection is unsurpassed—because the salt bath seals the work *automatically* from all atmosphere. Scaling, decarb and pitting are avoided.

Temperature control is closer, more accurate. The temperature will not vary more than 5°F. *in any part of the bath.*

The life of tools is increased from 25% to 300% over those heated by ordinary methods.

Adaptability—The Ajax Salt Bath handles any type of high speed, carbon or alloy tool and die steel. Moreover, it occupies less floor space, does not require a skilled operator and provides maximum protection and long life for pots.

Typical installation for hardening high speed tools. Preheat, high heat and quench furnaces. The center unit operating at 2350°F. is equipped with submerged electrodes (see illustration at upper right). Preheat and quench units have suspended electrodes.

Through this unique and patented Ajax submerged electrode design, the efficiency of salt bath hardening is increased in the following ways:

Power Consumption Decreased as Much as 30%—[illegible] bath exposed.

Electrode Life Greatly Extended—[illegible] oxidizing action at surface of bath.

Bath Rectification Simplified—[illegible] reduced due to restricted bath surface.

Restarting is Easy—Closely-[illegible] salt from top downward. No danger of sealed-in pressure. No damage to pot or electrodes.

Accurate Temperature Control—[illegible] within 5°F. throughout bath.

Overheating of Work Eliminated—[illegible] against back wall of furnace, prevent heating current from entering work. Entire bath depth available for work.

Salt Leaks Prevented—[illegible]

Easier Charging and Discharging—[illegible]

Write for Ajax Bulletin 123

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AJAX ELECTRIC SALT BATH FURNACES

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WITH **Gulf Lasupar Cutting Oil**

YOU GET THE ADVANTAGE OF INTENSIFIED CHEMICAL ACTIVITY WITHOUT OBJECTIONABLE ODOR

Already preferred by scores of shops because of its excellent performance characteristics, Gulf Lasupar Cutting Oil has been even further improved. Thanks to a special Gulf process, it now provides even greater sulphur activity over the entire range of a cutting operation.

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Gulf Lasupar Cutting Oil also contains a percentage of stable sulphurized fatty oil, effective in producing the fine finishes for which this quality cutting oil is so well known.

Operators everywhere will welcome the new Gulf Lasupar Cutting Oil—because they will get all these production advantages without the disagreeable odor ordinarily associated with sulphurized cutting oils.

Call in a Gulf Lubrication Engineer today and arrange to use Gulf Lasupar Cutting Oil on some of your tough machining jobs. Write, wire, or phone your nearest Gulf office or send the coupon below. Gulf Oil Corporation · Gulf Refining Company, Gulf Building, Pittsburgh, Pennsylvania.

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There's no question about proper machining practices for Republic ENDURO Stainless Steel Bars when you use this handy *Cutting Speed and Feed Selector.* Simple to use, it gives recommended feed/speed ratios for eight different stainless steels, including the ENDURO Free-Machining grades.

Republic's other machining aids include personal contact assistance by veteran machining experts and stainless steel metallurgists. Whatever your problem involving the fabrication of stainless steel, these men are ready and well-qualified to help you find the most efficient and economical solution in a hurry.

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Lindberg Engineering Company knows the importance of quickly and accurately determining the dew point of gases generated for heat treating furnaces. They know that customer satisfaction depends on continuous operation at a specific dew point for each individual installation. That is why they depend entirely on Alnor Dewpointers' accurate, consistent reading . . . in the field, laboratory, wherever precision checking is necessary for quality performance. That's why they report—"The Alnor Dewpointer is the best instrument we know for this purpose." Over 500 other large industrial concerns rely on Dewpointer precision and find the instrument pays for itself in the savings on CO_2 alone.

Faster . . . Easier . . . Consistently Accurate

★ Simple, direct operation of the Alnor Dewpointer assures laboratory accuracy by non-technical personnel. Substantial carrying case protects it against the usual hazards of portable use.

★ The Dewpointer is the only instrument of its kind that is a complete unit in itself . . . it is readily portable and does not require any external coolant or auxiliary apparatus. Operates on either AC or enclosed battery.

★ Indications take place in an enclosed chamber under conditions which can be controlled and reproduced . . . dew or fog is observed suspended in air—not on a polished surface as in other less accurate instruments.

★ Available in three ranges—for dew points between minus 20°F. and room temperature, from minus 80°F. to 0°F. and from minus 80° F. to room temperature.

Here's what you see!

The Dewpointer eliminates guesswork in determining dew points. You actually see the dew or fog suspended in the chamber.

SEND POST CARD FOR YOUR COPY OF NEW DEWPOINTER BULLETIN
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DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

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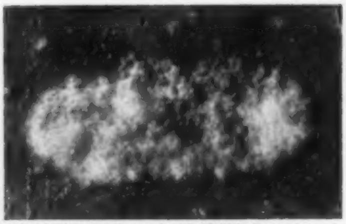
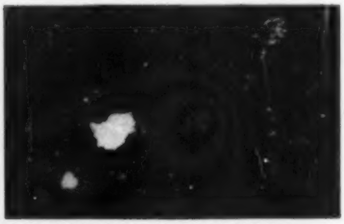
The RCA Electron Microscope, Type EMT



IN MEDICINE (Bacteria 20,000X). Bacteria and viruses can be studied to yield new data on morphology and structure.



IN CHEMISTRY (Road Dust 6000X). Extremely useful for studies of particle size, shape, and distribution.

IN METALLURGY (Stainless Steel 20,000X). Electron micrographs of metal specimens provide clearer representation of structure and surface detail.

A NEW LOW-COST ELECTRON MICROSCOPE

...for industry, medical science, and education

This new RCA Permanent Magnet Electron Microscope, Type EMT, brings the many advantages of electron microscopy within reach of more laboratories, schools, and hospitals. The use of Permanent Magnet lenses reduces bulk and achieves permanent stability of operation. Although the Type EMT costs only one-third as much as the larger research model, it fills the major requirements of research and control application. Its special features are compactness, simplicity, and ease of operation.

RCA's *new* Permanent Magnet Electron Microscope gives direct magnifications to 6000 diameters. A built-in camera makes it possible to obtain useful photo-enlargements to 40,000 diameters. Resolution extends to 100 Angstrom units, which is 20 times as powerful as the light microscope. Depth of focus extends to 10 microns, approximately 150 times that of the light microscope. Specimen images are viewed on a two-inch diameter screen. Specimens are inserted without breaking the vacuum.

The electron micrographs, appearing above, made with the new Table Model EMT, illustrate a few typical applications. We'll be glad to send you complete description and specifications. Just write, or use the coupon.

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RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

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Please send me information on RCA Electron Microscope, Type EMT.

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LEAD

The Standard Protective Sheathing for Cable

Twenty-seven ton cable-laying plow; it digs a trench in the ground—5 ft. deep, if necessary—feeds the cable into it, covers the cable and moves on, all in one continuous operation.

EXTRUDED lead tubing has been used as protective sheathing on overhead and underground electric cable for either voice or power transmission, since the late 1800's. The choice of lead for this purpose was dictated chiefly by a number of highly desirable characteristics inherent in the metal. The metal's pliability facilitates the reeling and unreeling of the cable; its low melting point permits the sheathing to be extruded over the core without damage to the insulation, and it is the only common metal which successfully withstands all of the corrosive influences encountered in the service-life of cable.

Lead alloyed with small amounts of other metallic elements is characterized by its relatively high tensile strength and resistance to fatigue – thus minimizing mechanical failure resulting from normal fatigue and tensile stresses. This is of especial importance since the stresses which are most likely to cause fatigue failure in aerial and duct cables are either oscillatory in nature or are the result of dimensional changes from alternate heating and cooling.

Of particular importance is the fact that lead is impervious to moisture and is highly resistant to atmospheric and soil corrosion or – in the case of oil-filled submarine power cable—to salt water corrosion. For lead exposed to the air develops its own protective film, usually an oxide, while the film that forms on lead buried in the ground may be silicate. Once these protective films have formed on lead the metal may be preserved indefinitely. Ample evidence to this effect is the lead pipe which, laid by the Romans nearly two thousand years ago, is still in use today.

Other factors in favor of lead sheathing is that it is malleable, and that convenient lengths of the cable are easily joined with the help of two other lead products, lead sleeves and solder. Finally, when the life of the cable is spent, the lead is easily reclaimed and can be returned to the market for another cycle of service.

ST. JOSEPH LEAD CO.

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

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Should your die needs require high resistance to abrasion, high hardness ratings, or if you are confronted with any difficulties in forming ferrous or non-ferrous metals, Finkl has a die block for your application, and a service engineer to help with your problems.

For over 70 years Finkl has produced quality products. This experience and knowledge is available to you in planning your forging production. Call or write any of the offices listed below.

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DIE BLOCKS AND INSERTS ★ PISTON RODS & RAMS ★ SOW BLOCKS ★ CRANKSHAFTS

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Why the sea is salty

In Norse mythology, a poor man got a magic mill from the elves. With it he could grind whatever he wanted--food, clothing, furniture, and best of all, gold. Of course, the poor peasant's lot changed from poverty to riches.

An envious brother borrowed the mill. He commanded it to "grind herrings and broth and grind them good and fast." But having taken the mill in such haste, he didn't know the magic words to shut it off. He was almost drowned in broth when the brother came to the rescue.

Finally, the magic mill was stolen by a salt dealer, who put it on his ship. Safely at sea, the skipper demanded, "Grind salt and grind it good and fast." Alas, he hadn't learned the control words either. The mill ground salt endlessly, filling all his kegs and his hold, covering the decks and at last sinking the ship. There at the bottom of the sea, so people say, the magic mill still grinds--and that's why the sea is salty.

From time immemorial, men have dreamed about magic mills and schemes to bring abundance and riches. Here in America, today, there are plans that are flooding us with superabundance of certain commodities. But what about the magic words to shut off the mill?

Isn't it time we see the truth in this ancient Norse myth, that "too much" is just as foolish as "too little?" We may well remember this first law of economics: In a *free* market, supply can adjust itself to demand--whether it be potatoes or steel--without sinking the ship. Here is a must job for all thinking Americans.

QUALITY YOUNGSTOWN SERVICE

The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio

Export Offices--500 Fifth Avenue, New York

MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

RAILROAD TRACK SPIKES - CONDUIT - HOT AND COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RODS - SHEETS - PLATES.

The Case of the Talkative Travelers

Word is really getting around about the advantages of using McKay Shielded-Arc Electrodes for weld fabricating and weld repairing of all types of steel.

You'll talk too, when you see how quickly and easily you can fill your particular electrode requirements from the complete McKay line. You'll like the ease of handling, the high deposition rate and the low spatter loss. Sound metallurgical deposits, free from porosity, and slag that is quickly removed enables you to do a better, cleaner welding job.

Standard McKay Electrodes are available for welding all types of mild-steels, alloy-steels and stainless-steels. And if you have a special welding job for which no standard electrode seems suitable, the McKay Research and Technical Staff will appreciate the opportunity of submitting recommendations.

Your inquiries are invited.

McKAY
ARC-WELDING
ELECTRODES
For MILD, STAINLESS & ALLOY STEELS

Full technical reports on all McKay *Mild*, Special-Purpose and Stainless-Steel Electrodes are available upon request. Write and tell us your specific interests.

THE McKAY COMPANY
403 McKAY BUILDING
Pittsburgh 22, Pa.

Hold It, Please — May We Remind You Of Something?

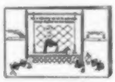
Something unusual about that bar of tool steel you are about to use. Labeled "Carpenter", it contains a "*plus alloy*" that holds remarkable promise for you.

It's an "alloy" that has *proved* it can give you a new freedom from die failures . . . new highs in output per grind . . . far fewer die headaches. Strangely enough, it's not a tangible alloy. But our Mill men swear it's there. They can prove it's made of patience, and human care, and skill—backed by production controls unequalled in the industry. It's the result of our decision years ago to meet a wide demand for tool steels that guarantee *unvarying* uniformity . . . and dependability above the ordinary.

And it is paying off a hundredfold in your every step from toolmaking through actual production!

Okay, put that bar to work. And remember: That "plus alloy" will *continue* to work for you . . . help you get *more* production from *present* equipment, through better tools and dies. The Carpenter Steel Co., 133 W. Bern St., Reading, Pa.

The Cone Test—One of many Carpenter quality controls. Exclusive with Carpenter, it checks and controls hardenability of water-hardening Matched Tool Steels—assures that sections of the same size will have uniform hardness penetration, shipment after shipment.



New useful booklet tells how to get *more* output from *present* equipment through simplified tool steel selection. For your copy, drop us a line on your Company letterhead.

Export Department: Woolworth Bldg., New York 7, N.Y.—"CARSTEELCO"

Carpenter

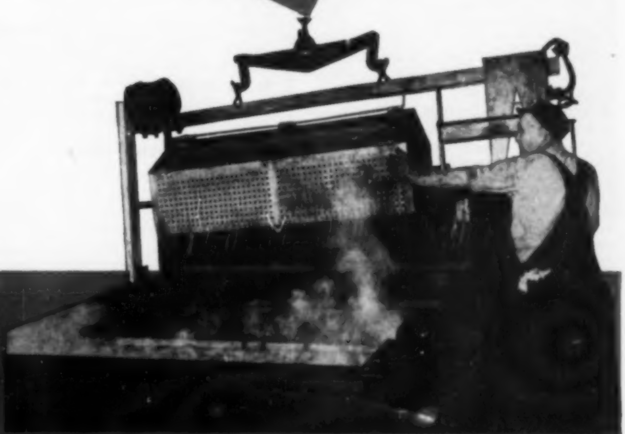
MATCHED TOOL & DIE STEELS

—containing the one "alloy" that has no price tag!

To get started now, just call Carpenter. Warehouse stocks in principal cities throughout the country.

ROLOCK

FABRICATED ALLOYS



A TUMBLING ACT

. . . FEATURING "One good turn after another"

Six years ago Rolock delivered this engineered-to-the-job monel motorized Tumbling Barrel to the Worcester Stamped Metal Co., Worcester, Mass. This barrel and, another one ordered after proof of efficiency was demonstrated, replaced former wooden crates requiring constant maintenance. Dimensions are 24" across the flats, 5' long. Weight 425 lbs., load 1500 to 2000 lbs. of steel stampings and castings...pickled in 10% solution of sulphuric acid.

Despite the fact that even some brass parts have been processed, both barrels are in excellent shape today and will continue to give many more profitable hours of service.

And long service is what you get with Rolock barrels, baskets, furnace muffles, pit type baskets, brazing trays, racks, etc., for all heat treating and finishing operations...built to handle larger loads, save time, improve work at lower costs. Try us... we make good!

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

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Easier Operation, Lower Cost

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Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Division, Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

SILICON . . . Deoxidizes, Increases Strength, and Improves Electrical Properties of Metals

Silicon is one of the most important elements used in the iron, steel, and non-ferrous industries. It is an efficient low-cost deoxidizer; and in larger amounts, it is also an effective alloying element.

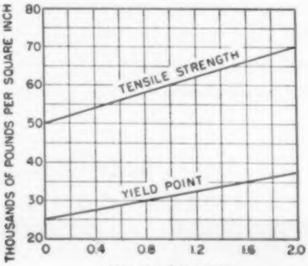
Efficient Deoxidizer

Silicon is used in practically all grades of carbon and alloy steels and offers an economical means of effectively eliminating oxides from the molten bath in all steel-making processes. Amounts up to about 0.80 per cent silicon are used for deoxidizing various steels used for forgings, wrought products, and castings.

Recent published research papers, covering work done in ELECTROMET's laboratories, have added greatly to the knowledge about the deoxidizing power of silicon by itself, and also in conjunction with other elements. Complete information is given in a report entitled "Solubility of Oxygen in Liquid Iron Containing Silicon and Manganese." If you would like a copy of this report, free of charge, write to the address above.

Improves Physical Properties

When used as an alloying element, silicon in small percentages will increase the tensile strength, yield point, and ductility of structural steels, such as those used for highly stressed parts of bridges. Some spring steels contain about 2 per cent silicon. Another application of silicon as an alloying element is in stainless steels, where it appreciably increases the resistance of these steels to certain types of corrosion and to high-temperature oxidation.



Effect of silicon on tensile strength and yield point of a steel containing approximately 0.10 per cent carbon.

Decreases Watt Loss

Silicon increases the magnetic permeability of steel. Hence silicon steel is specially suited for use as a "core" material in electrical generators, motors, transformers, electromagnets, and other electrical equipment. Because silicon decreases magnetic resistance, silicon steels show much lower eddy current losses. As a result, energy or watt losses are greatly decreased and tremendous overall savings are effected in the generation, transmission, and use of electrical power. Up to 5 per cent silicon is used in sheet steel for electrical apparatus.

Benefits Cast Iron

In cast iron, silicon not only serves as a deoxidizer but also has a marked graphitizing effect. Silicon tends to soften cast iron, thereby improving machinability and providing a control over depth of chill and physical properties. In larger amounts, sometimes as much as 14 per cent, silicon makes cast iron suitable for handling highly corrosive acids in chemical plants.

Improves Non-Ferrous Alloys

Silicon is used in non-ferrous alloys to increase strength and hardness, and to improve other physical properties. In various aluminum alloys, as much as 18 per cent silicon may be used. Copper alloys, too, frequently contain silicon: for example, the silicon bronzes.

Available Alloys

Silicon is produced by ELECTROMET in the forms listed below, which are suitable for every use of the iron, steel, and non-ferrous metal industry. For a complete description of these alloys, write to the address above for a copy of the 100-page booklet, "ELECTROMET Ferro-Alloys and Metals." This booklet describes over 50 metals and alloys produced by ELECTROMET and tells of the unique technical service offered to the metal industries.

The terms "Electromet," "EM," and "SMZ" are trade-marks of Union Carbide and Carbon Corporation.

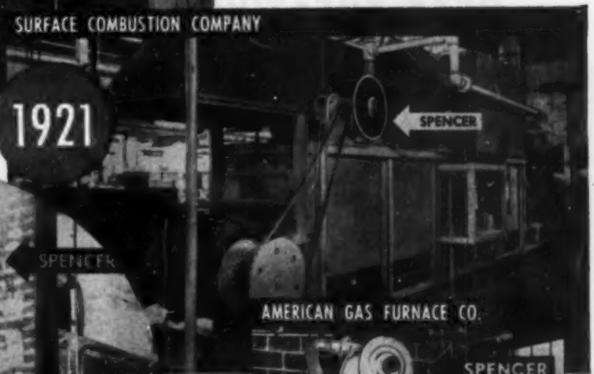
Alloys of Silicon and Their Uses

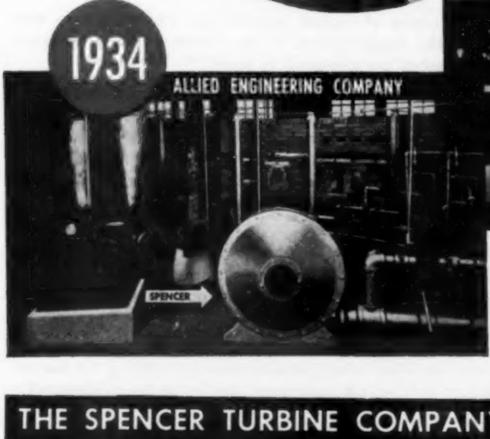
15% Ferrosilicon	In ground form, this alloy is used in the "sink and float" process of concentrating ores.
50% Ferrosilicon	Widely used as a deoxidizer; as a furnace block; and for adding silicon to fill specifications in the production of steel. Also used in the production of cast iron.
65% Ferrosilicon	Used mainly in the production of electrical sheet steel. (Available in low-aluminum grade only.)
75% Ferrosilicon	Used both as a deoxidizer and for alloying purposes in the production of steel, particularly steel containing high percentages of silicon. Also used for ladle additions to cast iron.
85% Ferrosilicon	Used for same general purposes as 75% ferrosilicon. Permits large silicon additions without harmful chilling effects.
90% Ferrosilicon	Used for same general purposes as 75% and 85% ferrosilicon. Permits large silicon additions without harmful chilling effects.
Silicon Metal	For use in the non-ferrous industry, particularly in the manufacture of aluminum and copper alloys. Also used to produce the organo-silicon compounds known as silicones.
Purified Silicon Metal	For special applications requiring silicon metal of the greatest purity.
"SMZ" Alloy	For ladle additions in the production of cast iron. Exerts strong graphitizing effect.
"ELECTROMET" Special Graphitizer	For ladle additions in the production of cast iron.
"EM" Silicon Briquets	For adding silicon to cast iron in the cupola or air furnace.
Silicomanganese	For adding silicon and manganese simultaneously in steel making processes.

Since 1917

The first Spencer Turbo wus installed in 1917. Many of the early machines are still in service. A few of the equipment manufacturers that have used Spencers consistently (see dates) for many years are represented on this page.

SPENCER TURBO COMPRESSORS





Standard sizes from 35 to 20,000 cu. ft.; ⅓ to 800 H.P.; 8 oz. to 10lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive construction available.

Special Spencer Bulletins are available as follows: Data, No. 107, Gas Boosters, No. 109, Four Bearing, No. 110, Blast Gates, No. 122. Foundries, No. 112 and the General Bulletin is No. 126.

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

No. 103 of a Series of Typical Installations

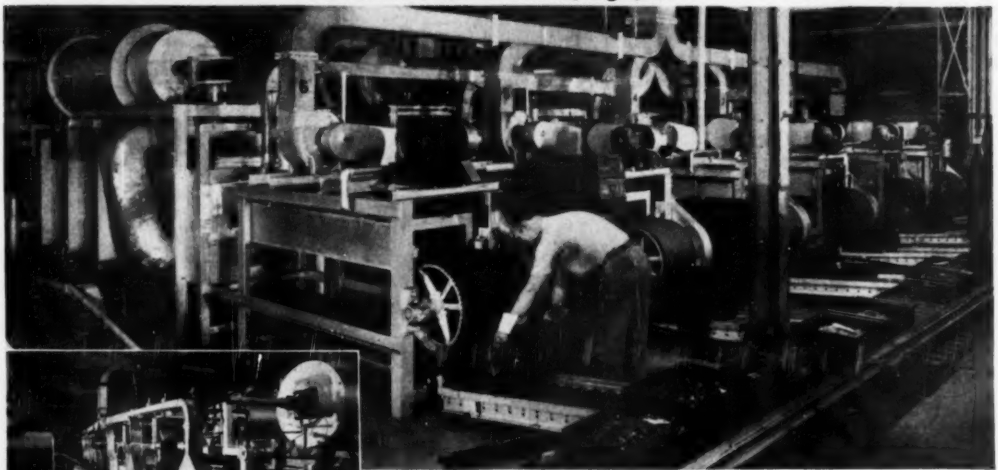
Sunbeam STEWART

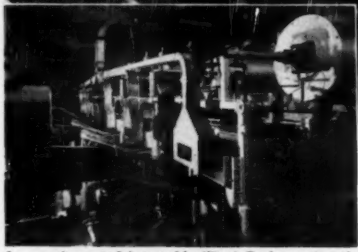
THE BEST INDUSTRIAL FURNACES MADE

HOW SUNBEAM STEWART FURNACES HELP MANUFACTURERS REDUCE COSTS AND KEEP THEMSELVES COMPETITIVE

HEAT TREATING SHAKEPROOF FASTENINGS

AT ILLINOIS TOOL WORKS, Elgin, Ill.





Because the parts fabricated by Illinois Tool are primarily small in size and vary considerably in their overall shape, a vibrator feed mechanism accurately positions work on the furnace belts.

Discharge end of the six Sunbeam Stewart continuous draw furnaces and the roller conveyor by which the boxes are conveyed to the inspection department. The method of inspecting the steel prior to fabrication, together with the close control of the processing throughout its manufacture—including heat treatment—has reduced scrap losses due to the heat treating equipment and men at Illinois Tool to less than ½ of 1 per cent.

A few of the many metal fastenings heat treated at the Elgin, Illinois plant of Shakeproof, Inc.—a Division of Illinois Tool Works. Hardness tolerance limits for a major share of Illinois products are held to a 5 point or less hardness range.

This is No. 103 in a series of typical installations demonstrating the wide variety of specific requirements in the metal-working industry Sunbeam Stewart furnaces are designed to meet.

One of the Illinois Tool Works' major fastening problems has offered a real challenge to the operation and control of heat treating equipment. This product is Sems, a pre-assembled screw and lock washer. The lock washer is held in a "free to rotate" position under the screw head by the screw thread rolling operation. Heat treatment requirements demand that both screw and lock washer are given a simultaneous draw—requiring the ultimate in temperature control.

The Sunbeam Stewart installation meets these "musts". Six continuous draw furnaces are employed in this work. The units are of the air-circulating, continuous belt type, each capable of delivering 600 pounds of material per hour. They are in use 24 hours a day, 5 days a week.

It will pay to consult Sunbeam Stewart on your heat treating problems. In addition to continuous conveyor units, Sunbeam Stewart builds a full line of standard furnaces and galvanizing equipment, gas or oil fired, electrically heated.

Sunbeam STEWART INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION

(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 108, 4433 Ogden Ave., Chicago 23 — New York Office: 322 W. 48th St., New York 19 — Detroit Office: 3049 E. Grand Blvd., Detroit
Canada Factory: 321 Weston Rd., So., Toronto 9

A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

Ready for delivery now — from warehouse stock!

Two TIMKEN® wear-resistant steels that do 90% of your hollow parts jobs!

If you need steel tubing in a hurry for making hollow parts, let Timken® 52100 and "Nickel-moly" help you out. These two general purpose steels offer good hardenability and wear resistance. Between them, they can do nine out of ten of your hollow parts jobs. And they are available from Timken in warehouse quantities for immediate delivery.

Write for free stock list now. And remember, you're sure of uniformity in both these steels—from tube to tube and order to order—because of Timken's rigid quality controls. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

1. 52100 TUBING

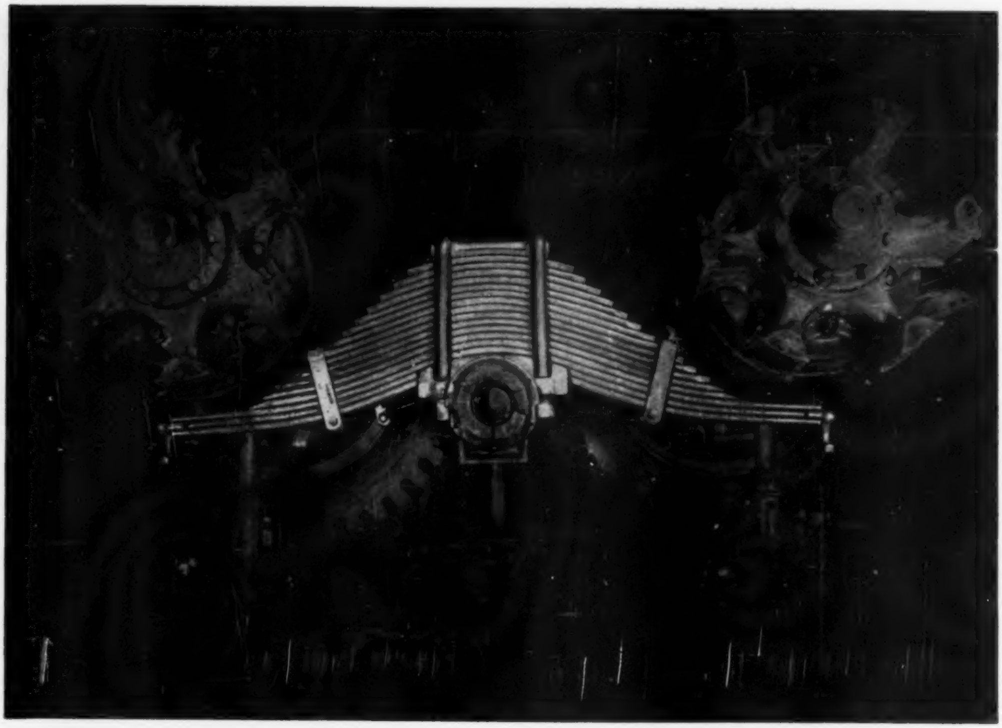
A high carbon chrome steel. A direct quenching steel which gives through hardness in moderate sections. Can be heat treated to file hardness and tempered back to any desired point. Frequently may be used in place of more expensive steels. Typical uses include: aircraft parts, slitter knives, bearing races, collets, pump parts, bushings. Available in 101 sizes, ranging from 1″ to 10½″ O.D.

2. "NICKEL-MOLY" TUBING

A low carbon nickel-moly steel. A carburizing steel which gives high surface hardness with a tough core. Has exceptional stamina and shock absorbing qualities when heat treated. Used for: piston pins, bearings, sleeves, knitting machinery, farm equipment, pump parts, bushings, perforating guns. Available in 52 sizes, from 1.389″ to 10.223″ O.D.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing



It doesn't pay to overgrade in selecting spring steels

In selecting spring steels it is generally considered sound practice to use grades whose alloy content is consistent with the thickness of the finished spring section. Springs of heavy section, for instance, usually require steel fairly rich in alloy content while those relatively light in section can be made economically from steel of medium or low alloy content.

But light or heavy, lean or rich, there are three properties that all spring steels must have for good results: superior impact value; excellent fatigue-resistance; and high yield point. A proper balance of these properties is needed to satisfy the mass requirements of the section as well as satisfactory response to heat treatment.

There is no short cut to economical selection of spring steels. It takes study and experience with various analyses and heat treatments. In this connection our metallurgists will be glad to help you arrive at the most economical solution. They will give unbiased advice based on long experience with all types of spring steels.

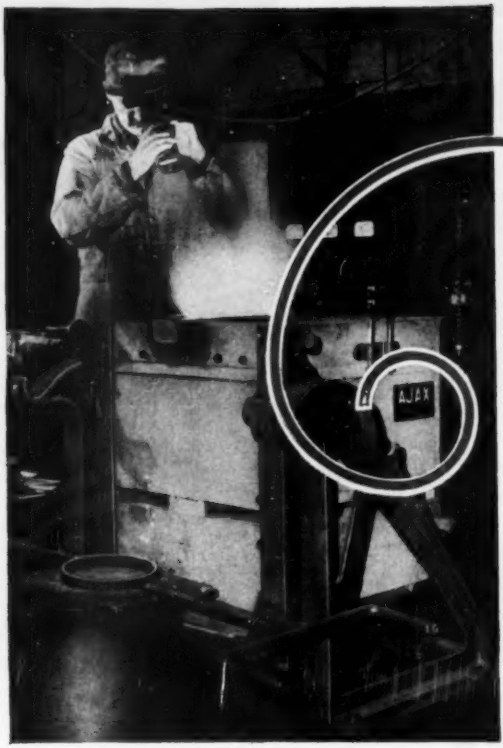
We manufacture the entire range of AISI steels as well as special grades and carbon steels.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation—Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM ALLOY STEELS



Casting Precision

STARTS IN THE MELT with

AJAX-NORTHRUP INDUCTION FURNACES

The precision that distinguishes fine castings must *start* in the melt . . . in precise control of composition, in accurate pouring temperature. The kind of control that only one furnace can provide . . . the Ajax-Northrup high frequency furnace. Take a look at the facts:

Speed: Speed is a function of power. Furnaces may be overpowered for extremely fast melting . . . normally or underpowered where slower melting schedules are permissible.

Analysis Control: In melting high alloy steels, alloying elements often can be kept within 0.25% of desired composition, carbon within 0.01 or 0.02%. Excellent, too, for "fussy" non-ferrous alloys. Because it stirs as it melts, you get uniform results heat after heat.

Economy: Fast melting minimizes oxidation, prevents loss of valuable alloy constituents, prolongs refractory life. It's the most economical way to melt metals high in chromium, nickel, tungsten, etc.

Flexibility: Makes no difference what metals you melt or what quantities . . . Ajax-Northrup's precision, speed, easy control, and flexibility in linings permit you to cover emergencies, meet almost any production schedule. Just name your alloys and quantities, and we'll send you the proper technical bulletins.

AJAX ELECTROTHERMIC CORPORATION
AJAX PARK • TRENTON 5, N. J.

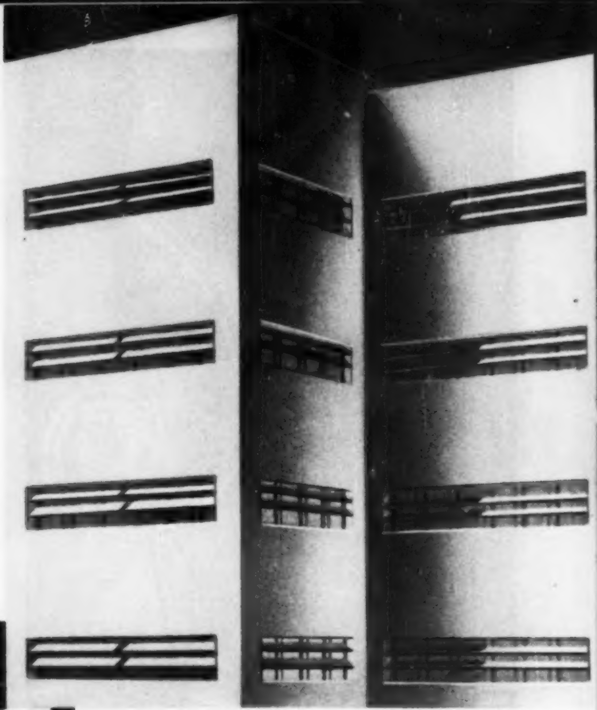
Associate Companies

AJAX ELECTRO METALLURGICAL CORP.
AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC.
AJAX ENGINEERING CORPORATION

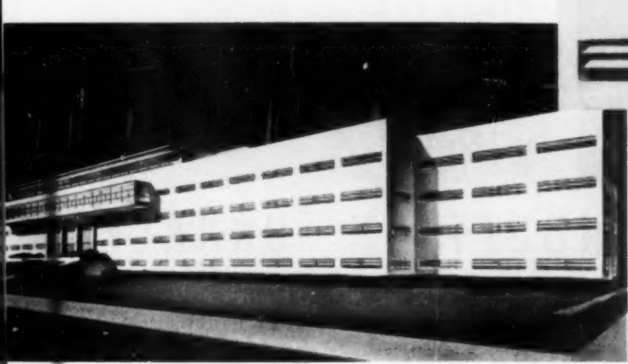
AJAX NORTHRUP

126

HEATING & MELTING



functional use as sun shades



gives added value to STAINLESS STEEL

Protection from the hot Alabama sun is a problem which has been solved for the Tennessee Coal, Iron and Railroad Company by the use of stainless steel sun shades on their new 4-story Flintridge Corporation office building at Fairfield.

These exterior horizontal solar shades, applied to 338 windows in sets of two, will cost about $100,000; but the architects, Holabird & Root & Burgee & Assoc., estimate that this amount will be more than offset by the smaller size air conditioning equipment made feasible through shading from the sun and the resulting space-saving of the smaller unit.

In addition to its functional use, stainless steel is noteworthy for its durability—of utmost importance in this particular installation as the building is adjacent to the manufacturing plants and subject to the usual atmospheric conditions of such a location. Its clean, bright surface is an attractive feature, and the economical advantage of its use has been proved by many records of long service life and very low maintenance cost.

We do not produce stainless steel but do make the alloy, ferro chromium, which gives it the stainless quality. Our VANCORAM Brand Ferro Chromium is produced by closely controlled processing methods from carefully selected raw materials to aid the steelmaker in the production of consistently high-grade steel.

MAKERS OF FERRO-ALLOYS

VANCORAM

CHEMICALS AND METALS

VANADIUM CORPORATION OF AMERICA

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with TOCCO* Induction Heating

THE Northwest Bolt and Nut Co. of Seattle installed a 50 kw 10,000 cycle TOCCO machine, to replace a conventional oil-fired slot type forging furnace, for heating bolt blanks for upsetting. Production on ½" diameter stock zoomed from 500 to 1500 pieces per hour—on ⅞" stock from 250 to 600 per hour.

50 kw 10,000 cycle TOCCO machine heating bolt blanks

ADDED ADVANTAGES

1. Uniform heating for better quality—fewer rejects
2. Much longer die life due to reduction of scale
3. Very low maintenance—compared with rebuilding brick-lined furnaces
4. No heating-up time required with TOCCO
5. Absence of heat and noise—for better working conditions

Why not have a TOCCO engineer find out how TOCCO can help reduce *your* forging, brazing, melting or hardening costs—no obligation.

See our CATALOG in SWEET'S FILE

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today

NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-1, Cleveland 1, Ohio

Please send copy of "Typical Results of TOCCO Induction Heating for Forming and Forging".

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Company ______

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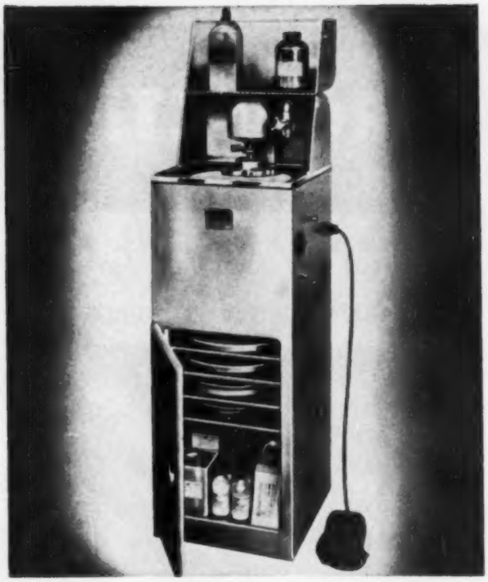


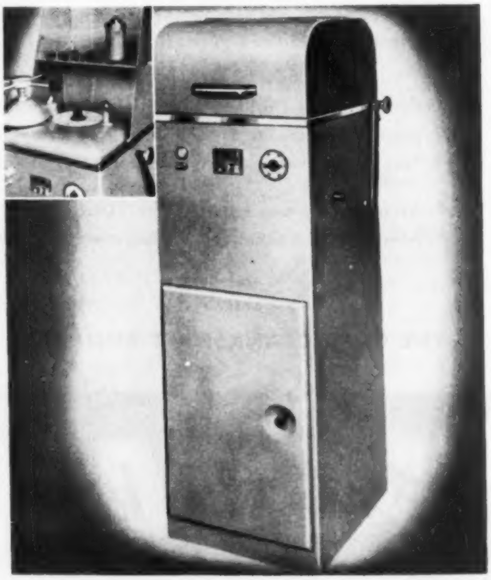
PRECISION Automatic Specimen-Polisher ideally completes 3-step technique (cutting, mounting, polishing) by *shearing*, not buffing or pulling, inclusions. Faster: about 30 minutes for 12 specimens. Uniform: no human variation. Lower cost: less skilled personnel-time, no spoiled specimens. Bulletin 5-513

For New *ECONOMY* in Laboratory Apparatus

lower cost, more volume—

Specify *Precision to be Sure

PRECISION Semi-Auto. Specimen Mounter for the second step in our noted 3-step technique. Self-contained unit with air-cylinder, automatically maintains pressure on specimen mount, relieves operator. Dual thermostatic heat control, pre-set air control, bell curing-timer. Saves space and trouble. Bulletin 5-713



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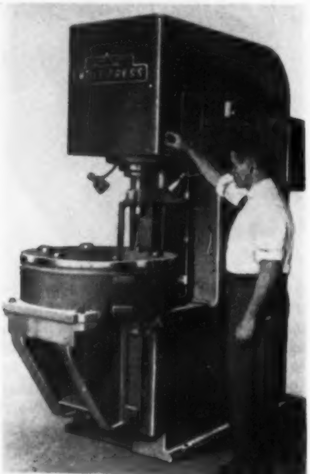
* *FINEST Research and Production Control Apparatus*

NEW YORK • PHILADELPHIA • ST. LOUIS • HOUSTON • SAN FRANCISCO

Engineering Digest of New Products

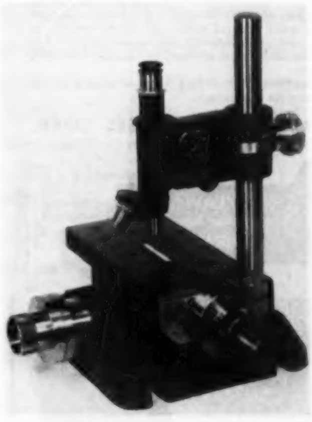
OIL-HYDRAULIC PRESS: Fast action with high-tonnage pressures under accurate, regulative control are announced operational advantages of the new 50-ton Multipress, oil-hydraulic press of The Denison Engineering



Co. Its precision adjustments for multiple ram action give unusual flexibility for application. It has a 15-in. stroke, 24-in. daylight opening, and a work surface of 31 x 19½ in., all of which provide more die space in keeping with their higher tonnage capacities. Approach of the ram to work is variable and can be preset at any speed desired up to a maximum of 290 in. per min., with pressing speeds up to 145 in. per min.
For further information circle No. 1 on literature request card on p. 32B

POWDER-SCARFING BLOWPIPE: Stainless steel slabs can be powder-scarfed with greater speed and economy with a new powder-scarfing blowpipe now being marketed by Linde Air Products Co. Known as the Oxweld FSP-2 powder-scarfing blowpipe, it incorporates an arrangement for external powder feed. A wider cut is made than was possible with earlier hand powder-scarfing blowpipes — 2 to 2¼ in., as contrasted with 1 to 1⅜ in. Due to increased speed, less powder is used per square foot of scarfed surface.
For further information circle No. 2 on literature request card on p. 32B

MICROSCOPE BASE: A compound microscope base for high precision inspection and measuring has been developed by Erb & Gray. Designed for tool, die and instrument makers, this base features a longitudinal travel of 6 in. and transverse travel of 4 in., with calibrated drums reading directly to 0.0001 in. Hold-down ears on 6-in. centers permit mounting on mills, jig borers, and surface tables, and the heavy dovetail ways permit large and unsymmetric parts to be bolted to the table. Examination of large parts is possible by means of an extension arm placing the microscope body 18 to 24 in. from the table. The base can be furnished with various optical combinations and is frequently supplied with a low-power stereoscopic microscope having a reference cross-line in



one eyepiece, or with special cross-hair disks indicating either dimensional or angular distances and tolerances.
For further information circle No. 3 on literature request card on p. 32B

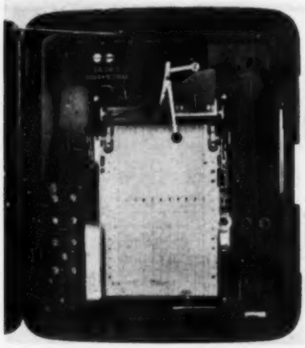
PORTABLE THICKNESS GAGE: Model 644 portable thickness gage, by Federal Products Corp., is used for rapid checking of sheet and strip stock. The measurement is quickly and accurately transferred to the full-

jeweled dial indicator, graduated 0.001 in., through the hardened steel upper and lower contact points. The wide-faced, spring-loaded upper and lower anvils grip and hold the gage perpendicular to the stock surface. The protecting lip at the front scoops and guides the stock into the gage. Chamfers on the anvils further facilitate entry of the stock. Indicator may be furnished with a direct or continuous reading dial, depending on use of the gage. For sorting purposes a direct reading dial is preferred. When checking thickness of plating, a balanced dial is more practical as it shows variations either side of zero which represent the nominal thickness of plating required.
For further information circle No. 4 on literature request card on p. 32B

HOT WORK DIE STEEL: Prestem, a new precipitation hardening die steel, is now being marketed by Heppenstall Co., in the form of solid press dies, insert dies, upsetter dies and punches. This steel is said to develop minimum heat checking, because of increased hardness after the precipitation (tempering) treatment. When dies are tempered at 950° F., hardness is Rockwell C-45 to 48; if tempered at 1050° F. the hardness range will be Rockwell C-49 to 52.
For further information circle No. 5 on literature request card on p. 32B

Engineering Digest of New Products

SR-4 STRAIN RECORDER: New Baldwin strip chart strain recorder for continuous measurement of surface strain in structures or machines by means of SR-4 resistance wire

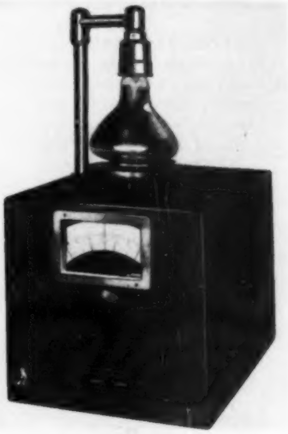


strain gages is announced by The Baldwin Locomotive Works. The recorder is an electronic-type instrument designed and calibrated for use with two SR-4 gages having a resistance of 120 ± 1.2 ohms and a sensitivity factor between 1.9 and 2.2.

Available ranges in the instrument are 0-2000, 0-5000, and 0-10,000 microinches per inch. It provides ten chart speeds within a range of ¾ to 720 in. per hour or 12 in. per minute. The pen moves across a 4½-in. wide chart in a straight line, thus making coordinated readings of time vs. strain simple. Instruments are available with full scale traverse speeds of one, three or five seconds without overshoot.

For further information circle No. 6 on literature request card on p. 32B

MOISTURE TESTER: A new moisture tester developed by the Claud S. Gordon Co. offers several advantages in determining the moisture content of foundry sands and similar materials. The operation of the unit is so simple that a skilled operator is not required and tests can be made at any location where an electrical connection is available. The gravimeter principle employed in the instrument, besides giving definite and reliable results, makes the determination test quickly and automatically — showing the moisture percentage on a dial.



Depending on the moisture content of the sample, a complete test can be made in from 2 to 5 min. The instrument is self-contained, complete with sensitive balance and heat bulb for drying the material by radiant heat.

For further information circle No. 7 on literature request card on p. 32B

DUCTILITY TESTING MACHINE: A new ductility testing machine providing a total capacity of 250,000 lb. pressure and incorporating a 5-in. diameter penetrator has been made by Steel City Testing Machines, Inc. The machine is motorized, hydraulically operated, and provides separate controls for clamping the sample and for regulating the penetrating pressure, which can be applied up to 150,000 lb. while clamping pressures are provided up to 100,000 lb. Although the conventional ⅞-in. diameter penetrator used in most ductility testing machines satisfactorily determines the ductility of deep drawing steel, it was felt that cup testing over a larger area would afford a greater opportunity of detecting surface and subsurface imperfections. A short ⅞-in. diameter extension on top of the 5-in. diameter penetrator affords an opportunity for comparison with the ⅞-in. standard method.

For further information circle No. 8 on literature request card on p. 32B

Ten Years' Service & Never Relined at NEWPORT NEWS CO.

Here's an enthusiastic user that now has five Delaware Furnaces. The first has been in service ten years and never required relining.

Delaware Furnaces are known for economy in maintenance as well as fuel. There's economy, too, in that one furnace does every heat treating job on every type of steel. Simplified atmosphere control assures work free of scale and de-carburization.

YOU can *confidently* and *economically* heat treat in your own shop with the easy-to-operate Delaware Furnace.

INFORMATIVE DATA is in 16-page Bulletin F-1. Send for your copy.

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Operating Range 1200 to 2800° F.

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Controlled Atmosphere
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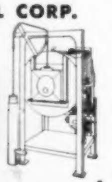

★ ★ ★ STRAIGHT FACTS on Controlled Atmosphere are included in DELAWARE BULLETIN F-1.

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WILMINGTON 99, DELAWARE

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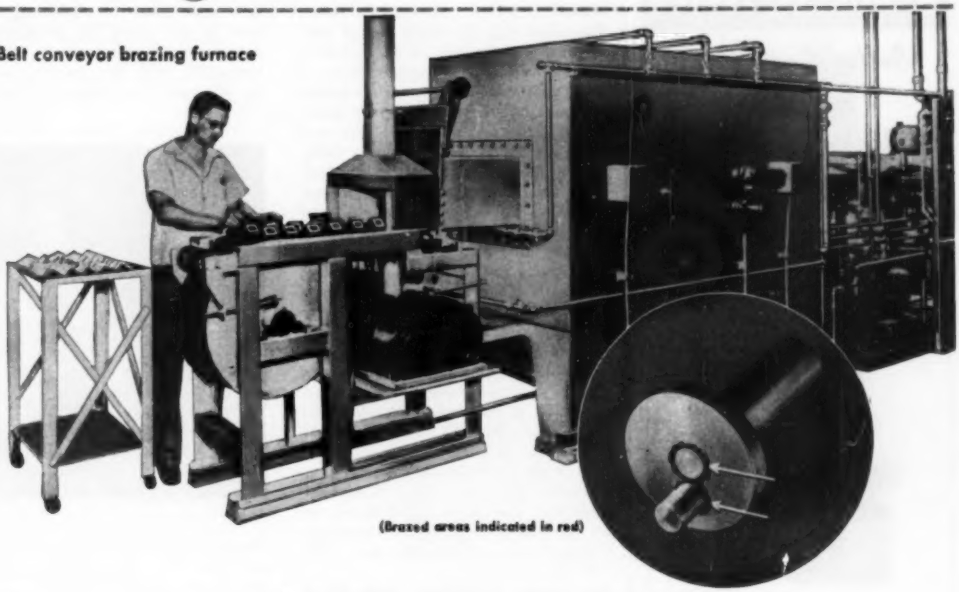
Belt conveyor brazing furnace



(Brazed areas indicated in red)

$1,120 SAVED

every 8 working hours with Westinghouse Brazing

Four cents per unit! $1,120 every eight hours. That's what one manufacturer saved when he switched from machining to Westinghouse brazing. With production of 3,500 units per hour, each furnace produced these startling savings.

Why spend dollars? Braze it for pennies with Westinghouse equipment. The Westinghouse brazing furnace is only one of a wide variety of furnaces—both gas-fired and electric—produced by Westinghouse.

For either gas-fired or electric operation, Westinghouse can make thorough, impartial recommendations for the type of equipment needed to handle your heat-treating problem most economically. Get all the facts today. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, 181 Mercer Street, Meadville, Pennsylvania. J-10347

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ENGINEERS—Thermal, design and metallurgical engineers to help you study your heat-treating problems with a view toward recommending specific heat-treating furnaces and atmospheres.

RESEARCH—A well-equipped metallurgical laboratory in which to run test samples to demonstrate the finish, hardness, and metallurgical results that can be expected on a production basis.

PRODUCTION—A modern plant devoted entirely to industrial heating.

EXPERIENCE—Manufacturers of a wide variety of furnaces—both gas and electric—and protective atmosphere generators.

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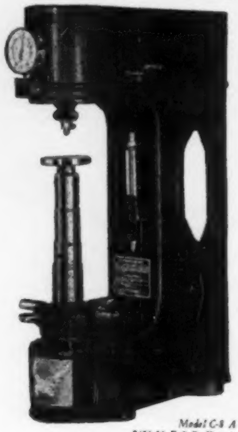

Model C-8 A
$450.00 F.O.B. Detroit
Complete with diamond penetrator

For your "Rockwell" testing, you want an instrument that gives you results of unquestioned accuracy. Years of research have gone into making the CLARK Hardness Tester just such a precision instrument.

The CLARK gives you accurate results for every production requirement. It is durably built to give you years of dependable service. It is fast and simple to operate; easy to maintain. Compare the CLARK and see for yourself how much more it has to offer.

CLARK

INSTRUMENT, INC.
10200 Ford Road • Dearborn, Michigan

Engineering Digest of New Products

HELIWELDING ELECTRODES: Thoriated tungsten, long used in electronic tubes because of its excellent electron emission characteristics, is now available as a nonconsumable electrode (Airco Thor-Tung) for inert-gas-shielded arc welding. This new electrode has proved extremely valuable in d-c. straight-polarity welding. Tests have shown that Thor-Tung operates much cooler than standard tungsten electrodes, thus permitting the use of higher currents on electrodes of a given size. Arc stability is excellent, not only at these high currents, but also at currents lower than those possible with conventional tungsten electrodes. Because of its permanence, the thoriated electrodes may be "pointed" to permit continued operation at extremely low currents.

The d-c. straight-polarity method of shielded welding aluminum, using Thor-Tung electrodes and helium as a shielding gas, not only eliminates problems heretofore encountered in a-c. shielded welding, but also provides a hotter, more stable and more efficient arc.

For further information circle No. 9 on literature request card on p. 32B

CARBON DETERMINATION: Large savings in the time required for making a determination of carbon in steel are possible by use of the new induction carbon apparatus announced by Fisher Scientific Co. The new apparatus employs a quartz sample holder and an induction-type coil which heats the sample with radio frequency energy. Ignition takes place within two minutes and the assembly also includes a platinum wire catalyst for converting any CO into CO_2. The CO_2 formed by the ignition passes through an absorber to remove SO_2, then is absorbed in the CO_2 absorbent. In a series of tests with National Bureau of Standards samples, it was found that accuracy of results was plus or minus 0.005%. The instrument will handle a wide variety of ferrous alloys with carbon contents ranging from 0.072 to 5.10%. The new apparatus operates on 230 volts, 50 to 60-cycle a.c. and is furnished with necessary chemicals.

For further information circle No. 10 on literature request card on p. 32B

LARGE DIAMETER CYLINDERS: Completely redesigned, and available in a wide range of mounting styles, new 14 and 16-in. low pressure cylinders for 125 psi., air, or 160 psi., hydraulic, have just been announced by Hannifin Corporation. Cup-type

pistons and chevron-type gland packings make the new cylinders suitable for air, oil, or water service.

Users' design problems are simplified by the fact that the compact, rugged end caps are furnished to the same mounting dimensions either cushioned or noncushioned. Two large pipe ports are drilled in each cap — 1 in. in the 14-in. bore size, 1¼ in. in the 16-in. size. Double-end rods are available in most mounting styles.

For further information circle No. 11 on literature request card on p. 32B

TUMBLING MACHINE: A new tumbling machine designed with an increased capacity for grinding, deburring and finishing metal parts is now being offered by the Grav-i-Flo Corp. The new machine has a 68-in. width x 64-in. depth x 68-in. height, with two 24 x 40-in. i.d. compartments. Other features contributing to the improved design of the machine include: compartments furnished with ½-in. plate unlined or ¼-in. plate rubber-lined, doors having cam locks with manually released safety stops to provide pressure relief, and a limit switch on the safety guard to cut off current and stop barrel rotation when guard is lifted. Water and electrical services are integral with the machine.

For further information circle No. 12 on literature request card on p. 32B

13. Alloy Annealing Slide Chart
Annealing data for the principal analyses alloy steels is contained in a convenient slide ch On one side is listed data for producing sphero structures in 40 alloy types by both conventi and isothermal annealing processes. The rev side carries data for producing lamellar structu also broken down by conventional and isother processes. *Republic Steel Corp.*

14. Alloy Brazing
New bulletin 20 covers silver alloy brazing Easy-Flo and Silfos. Tells where and how to these alloys to the best advantage. Shows m interesting applications; describes fast bra techniques. *Handy & Harman.*

15. Alloys
New catalog, "Electromet Ferro-Alloys Metals", lists over 50 metals and alloys describes unique technical service offered to metal industries. *Electro Metallurgical Div.*

16. Alloys, Nickel
New technical bulletin T-6 discusses resist of nickel and its alloys to corrosion by cau alkalies. *International Nickel Co.*

17. Belts, Metal
Bulletin 47P illustrates and describes comp line of wire belts for industry. *Ashw Brothers, Inc.*

18. Blast Cleaning
There is a Pangborn rotoblast table, barrel table-room designed to bring you amazing savi Write for bulletin 214. *Pangborn Corp.*

19. Camera, High Speed
"Magnifying Time", a new folder descri high-speed camera capable of 1000 to 3000 tures per second. Particularly adaptable for c inspection in machine tool operations and also measuring flow of liquids as in chemical mi coolant flow, etc. *Eastman Kodak Co.*

20. Carbon Determination
6-page bulletin describes new induction ca apparatus for faster carbon determinations. cusses operation and cites typical results. *Fi Scientific Co.*

21. Castings, Steel
New bulletin describes Pyrasteel, the chromi nickel-silicon alloy for resisting oxidation corrosion up to 2000°F and for withstanding concentrated or dilute commercial acids and rosive gases. *Chicago Steel Foundry Co.*

22. Control Devices
New 64-page catalog 8303 illustrates over different industrial control devices for temperat flow, pressure, liquid level, and humidity. *Br Instrument Div.*

23. Controlled Atmospheres
Bulletin available on new Alnor Dewpointer accurate, consistent reading of atmosphere in f laboratory. Readily portable, operating on A enclosed battery. Furnished in three ra between 20°F and room temperature, from mi 100°F to 0°F and from minus 80°F to r temperature. *Illinois Testing Labs.*

24. Controller
Potentiotrol, a potentiometer controller, ope ing with the Wheelco "Electronic Link" descri in bulletin. *Wheelco Instruments Co.*

25. Cutting Oils
Special Gulf process for providing greater sulp activity over the entire range of cutting operati described in new pamphlet "Gulf Lasupar Cut Oil". *Gulf Oil Corp.*

26. Degreasing
28-page vapor degreasing manual descr process, gives advantages and basic design. Ty of degreasers, operation and solvents are discus *Optimus Equipment Co.*

27. Electrodes
New 12-page booklet, "The ABC's of Wel High Tensile Steels", guides buyers and user low-alloy, low-hydrogen electrodes. *Arcos C*

28. Electrodes, Welding
New catalog presents complete line of shiel arc electrodes for welding of mild steels and a steels; includes specifications, mechanical prope and applications. *McKay Co.*

29. Electron Microscope
The new table model RCA electron micros is described and illustrated in a 12-page boo *Radio Corp. of America.*

30. Electropolisher
Bulletin on theory and practice of electrol polishing of metallurgical samples with descrip of the Buehler-Waisman Electropolis *Buehler, Ltd.*

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Bulletin TC-8 is 42 pages of detailed facts and charts on all standard thermocouples, radiation detectors and resistance bulbs. It's a convenient reference for knowing when and how particular sensing units and control accessories should be used on indicating, controlling and recording instruments.

Essential data pertaining to making, checking, selecting and ordering thermocouples; wire sizes and resistances and temperature-millivolt curves make this manual a valuable asset in applying indicating, controlling and recording instruments.

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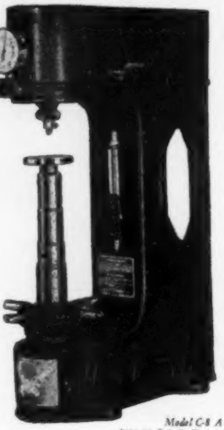

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$450.00 F.O.B. Detroit
Complete with diamond penetrator

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The CLARK gives you accurate results for every production requirement. It is durably built to give you years of dependable service. It is fast and simple to operate; easy to maintain. Compare the CLARK and see for yourself how much more it has to offer.

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30. Electropolisher

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WHAT'S NEW

IN MANUFACTURERS' LITERAT

31. Fasteners

Complete file folder contains illustrations and engineering descriptions of fasteners and fittings for resistance welding, adjusting screws, adjustable feet and other products. *Ohio Nut & Bolt Co.*

32. Finishes

New "Black Book" gives full details on Black Magic finishes for steel, iron, zinc, cadmium, copper and its alloys. *Mitchell-Bradford Chemical Co.*

33. Finishes

Full information and samples on Iridite Al-Coat finishes for aluminum surfaces. *Allied Research Products.*

34. Finishing

Alodine coating chemical protects aluminum and its alloys with no plating equipment required. Applied with dip, spray, brush and flow coat, it provides a simple, easy process for lasting, corrosion-resistant finish. *American Chemical Paint Co.*

35. Finishing

8-page booklet describes Pylumin process for protecting aluminum, either painted or unpainted. *Pyrene Mfg. Co.*

36. Furnace

New bulletin HD-664 describes heavy duty car bottom nitriding furnaces for producing nitrided parts for aircraft engines and heavy machinery items at greater saving of cost. *Hevi Duty Electric Co.*

37. Furnace Atmosphere

Bulletin F-1 gives full description of versatile, controlled-atmosphere furnace for all steels from high carbon to high speed in range 1200–2800°F. *Delaware Tool Steel Corp.*

38. Furnaces

Bulletin No. 78 describes furnaces especially designed for heat treating of small parts to eliminate lost time in sending work out for processing. *Cooley Electric Mfg. Co.*

39. Furnaces, Atmosphere

New comprehensive bulletin SC-148 describes complete line of standard rated atmosphere furnaces. Shows five different furnaces, including the Balco, Char-Mo, Atmotrol, Vertical and Horizontal Muffle furnace. *Surface Combustion Corp.*

40. Furnaces, High Temperature

Fully descriptive brochures on research and production furnaces for annealing, brazing, and routine heat-treating problems. *Harper Electric Furnace Co.*

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41. Furnaces, Rotary
Bulletins 801-804 and 1210-1212 illustrate and describe various continuous and batch rotary furnaces suitable for carburizing and other general and atmosphere heat treatment. *American Gas Furnace Co.*

42. Gas Cutting Machine
Full information furnished in descriptive folder ADC-660 on new Airco No. 3 Monograph for gas cutting of special structural shapes, straight line, circle and bevel, with a high degree of accuracy. *Air Reduction Sales Co.*

43. Gas Generator
Bulletin 1-11 describes how new inert gas generator Model 1 M1HE, rated at 1000 c.f.h., obtains the same analysis of inert gas, regardless of demand. Fully automatic, it gives accurate proportioning and assures precise analysis over full operating range. Ratio control adjusts for manufactured, natural, propane, butane or refinery gases. *C. M. Kemp Mfg. Co.*

44. Gears
Information on all types of gearing specifications including Neloy, spur, bevel, mitre, Sykes Herringbone, available in bulletin No. 9, sent on request. *National Erie Corp.*

45. Hard Metal Drilling Machine
Illustrated 4-page folder on the new Elox Electron Drill, hard metal drilling machine with motor-driven automatic feed guaranteed to equal or exceed the speed of twist drilling. Complete with cutting speed charts. *Elox Corp of Michigan.*

46. Hardness Tester
Illustrated circular describing the Ames portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision Machine Works.*

47. Hardness Tester
Bulletin ET 12 gives description of the new Ernst portable hardness tester for quick, accurate, direct readings without reference to conversion scales or calculations. *Newage International, Inc.*

48. Hardness Testers
Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

49. Heat Treating
Bulletin 123 describes how production is doubled, surface protection improved, and life of tools increased through the use of Ajax salt bath heat treating equipment. *Ajax Electric Co.*

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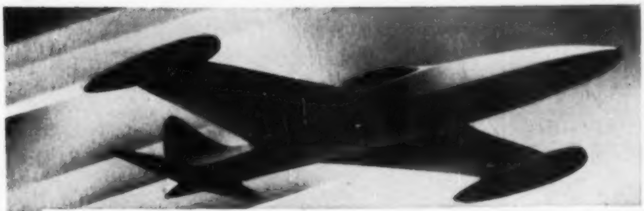

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BONDS PAINT TO ALUMINUM AND PROTECTS THE METAL

EASY TO USE
Process is foolproof and chemical solution can be applied by dipping, spraying, brushing or flow-coating.

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Alodizing is a chemical conversion process.

ECONOMICAL
Low chemical cost, short coating time and low temperature keep overhead down.

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The tough, durable Alodized surface makes paint stick to aluminum and resists corrosion. "Alodine" meets these Service specifications: MIL-C-5541; MIL-S-5002; AN-E-19; AN-F-20.

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WHAT'S NEW

IN MANUFACTURERS' LITERATUR

50. Heat Treating

Folder describes new improved Pentrate process for rapid, durable, economical black finishing for steel. *Heatbath Corp.*

51. Heavy-Duty Forgings

16-page booklet on "Heavy-Duty Forgings", profusely illustrated, shows forgings of all sizes in every phase of development from ingot to finished product. *A. Finkl & Sons Co.*

52. Industrial Furnaces

6-page folder describes 18 typical installations of gas-fired, oil-fired and electric furnaces of various types, complete with specially designed equipment for bright annealing, scale-free hardening, carbon restoration, carburizing and production heat treatment. *Electric Furnace Co.*

53. Laboratory Equipment

New precision automatic specimen-polisher for completing 3-step technique — cutting, mounting, polishing by shearing, not buffing or pulling — described in bulletin 5-513. *Precision Scientific Co.*

54. Load Testing

Brochure 501 gives full details on universal testing machines in three ranges: Model TMU-A, 0–30,000, 0–6000, 0–600 lbs. Model TMU-B, 0–15,000, 0–3000, 0–300 lbs. *National Forge & Ordnance Co.*

55. Lubrication of Hot Metals

New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal-forming operations. *Acheson Colloids Corp.*

56. Machine Design

Fundamentals of producing low-cost machine parts — design, material and treatment — are discussed in 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

57. Melting

Pot melting of soft metals and salts. Automatic gas firing systems, instruments, burners, valves, blowers. *Partlow Corp.*

58. Metal Cleaner

New booklet, "Buffing Compound Removal Was a Tough Job", gives complete information on latest development in metal cleaning research. *Cowles Chemical Co.*

59. Metallography

Catalog E-210 describes photomicrography equipment model L, with proper accessories to meet all requirements for high and low photocopying. *Bausch & Lomb Optical Co.*

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METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

January, 1951

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6-page folder describes 18 typical installations of gas-fired, oil-fired and electric furnaces of various types, complete with specially designed equipment for bright annealing, scale-free hardening, carbon restoration, carburizing and production heat treatment. *Electric Furnace Co.*

53. Laboratory Equipment
New precision automatic specimen-polisher for completing 3-step technique — cutting, mounting, polishing by shearing, not buffing or pulling — described in bulletin 5-513. *Precision Scientific Co.*

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Brochure 501 gives full details on universal testing machines in three ranges: Model TMU-A, 0-30,000, 0-6000, 0-600 lbs. Model TMU-B, 0-15,000, 0-3000, 0-300 lbs. *National Forge & Ordnance Co.*

55. Lubrication of Hot Metals
New bulletin 426 describes how (DAG) colloidal graphite can solve your lubrication problems in hot metal-forming operations. *Acheson Colloids Corp.*

56. Machine Design
Fundamentals of producing low-cost machine parts — design, material and treatment — are discussed in 72-page "Three Keys to Satisfaction". *Climax Molybdenum Co.*

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New booklet, "Buffing Compound Removal Was a Tough Job", gives complete information on latest development in metal cleaning research. *Cowles Chemical Co.*

59. Metallography
Catalog E-210 describes photomicrography equipment model L, with proper accessories to meet all requirements for high and low photocopying. *Bausch & Lomb Optical Co.*

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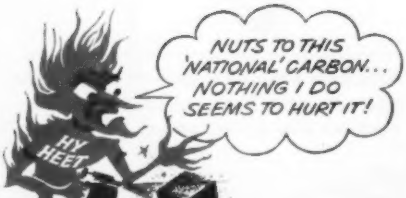
15 blast furnaces in the U. S. have each produced over 1,000,000 tons of iron on a single "National" carbon lining . . . and are still going strong!



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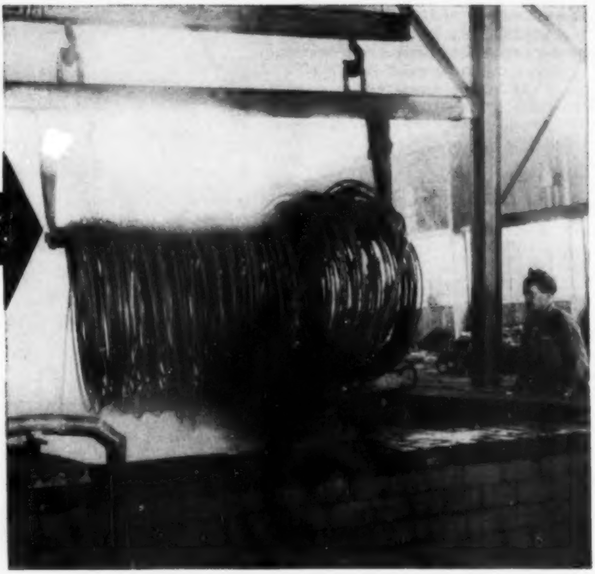

The high strength of Hastelloy alloys makes possible the lightweight construction of equipment from standard wrought forms. The hooks in this pickling assembly handle 3,000 lb. of coiled wire or bar stock, and they are made from much lighter gage sheet than would be required if steel had been used.

Corrosion rate in agitated solution less than 0.007 in. per year

This Hastelloy alloy pickling assembly operates in a violently agitated, heated solution of sulphuric acid. The solution is oxidizing in nature at the liquid level, and strikes against the assembly at high velocities. In the face of these severe conditions, the corrosion rate of the assembly is only 0.002 to 0.007 in. per year.

Hastelloy alloys were selected for this job because of their high strength, light weight, and ease of fabrication, as well as their superior corrosion resistance.

You will find that the fabrication of equipment from wrought or cast Hastelloy alloy is an economical solution to many tough corrosion problems involved in modern steel processing. There are four grades of this versatile material of construction—each specially designed to resist certain common mineral acids and oxidizing agents, even at elevated temperatures. They can be readily fabricated by most common methods. Procedures are generally the same as those used to fabricate the austenitic stainless steels.

If you would like samples of Hastelloy alloys to try out under your own operating conditions, fill out the handy coupon below. Descriptive literature and price lists are also available, without obligation.

Here is the Hastelloy alloy clad yoke bar and trunnion before assembly.

The I-section is joined to the hook with Hastelloy alloy welding rod.

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The only way to meet high physicals with lean alloy steels

Yes, the right quench, the faster quench, is an absolute necessity if you must use steels of low nickel and chrome, yet meet high tensile and yield "specs".

WHEN you use an oil made solely for quenching . . . one which absorbs heat faster . . . one which maintains uniform quenching speed regardless of bath temperature . . . one made for speedy, deep hardening . . .

THEN, and then only, will results be uniformly satisfactory. Then, and then only, will you be able to use lower alloy steels and exceed required physicals—not fail to meet them.

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Ready to give you on-the-job service . . .

HERE IS AN OUTSTANDING FAMILY of insulating fire brick for back-up or exposed use . . . the only family of its kind . . . that gives you a complete range . . . a *quick heating* insulating fire brick for every purpose.

By taking advantage of the quick heating characteristics of these insulating fire brick, you'll benefit through important savings in fuel because of the quicker rise to proper operating temperature in the furnace. This is a result of the low heat storage capacity and low thermal conductivity characteristics of the brick. These factors are especially important where furnaces are being intermittently operated.

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Why not have a Johns-Manville insulation expert call to tell you more about ways in which you can save by using these insulations in your furnaces. Write Johns-Manville, Box 290, New York 16, N. Y. for further information.

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage,† percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.20
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2000 F	2350 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

† 24-hr simulative service panel test for JM-3000; 24-hr soaking period for other brick.

* Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

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Johns-Manville First in INSULATIONS

Now, more than ever before, America must make full use of its steel-making capacity and conserve its natural resources. Now, more than ever, there is national significance in the phrases, "*Make a ton of sheet steel go farther*" and "*Make your product last longer.*"

These low-alloy, high-tensile steels do "make a ton of sheet steel go farther"—for their inherently higher strength is 50% greater than mild carbon steel. That means, in turn, that 25% less section can be used with safety, and where rigidity is important, this can usually be compensated for through slight design change.

"Make your product last longer" is no idle claim. The much greater resistance of N-A-X HIGH-TENSILE to corrosion, abrasion, and fatigue assures longer lasting products even at reduced thickness.

Explore the potential economies to be derived from the use of low-alloy, high-strength steels—and then specify them. Their use can add materially to our national conservation program.

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*The assurance of a continuous supply of Titanium to make stabilized austenitic chromium nickel steel...plus the economic advantage of the lower price of type 321 has focused increasing attention on its other outstanding features. Among these are excellent high temperature properties, thermal shock resistance and ease of drawing and forming.

In the "as-welded" state, as normally used, 321 shows a high order of corrosion resistance in a variety of corrosive media. It is being used effectively in many installations with type 347 weld rods used in welding.

* In developing the Low Carbon Ferro Titanium alloys used in making 321 stainless, TAM has acquired much worthwhile technical data. Therefore, although we do not supply steel, we can supply you with information of value. Write our New York City Office.

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For accurate temperature measurement, use meters calibrated for Chromel-Alumel thermocouples

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And for good reasons, too. Because CHROMEL-ALUMEL thermocouple wire carries a positive accuracy guarantee . . . ±5° F. at temperatures up to 660° F., and ±¾% from 660° F. and over. It's highly responsive to temperature fluctuations . . . so resistant to oxidation that you need not pack the protection tube . . . and it maintains its fine accuracy over longer periods of time than any other base metal thermocouple material. So if you're responsible for accurate temperature measurement, better check your pyrometers to make sure they're properly calibrated, then specify couples by name . . . CHROMEL-ALUMEL thermocouples. Available through your instrument manufacturer or pyrometer service company.

PS-And while you're at it . . . complete your chain of accuracy with CHROMEL-ALUMEL "extension" leads. For, by using wires of identical compositions for both couples and leads, you eliminate all possibility of "cold-end" errors.

Complete technical information is contained in our Catalog 59-R . . . want a copy?

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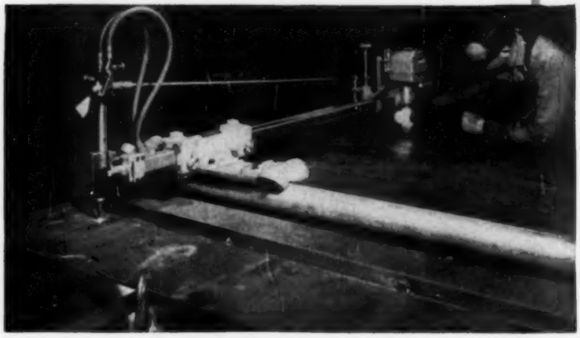
**the [illegible] ckel-chromium resistance alloy that first made electrical heating practical*

"We can't say enough about Airco's NEW No. 3 Monograph . . .



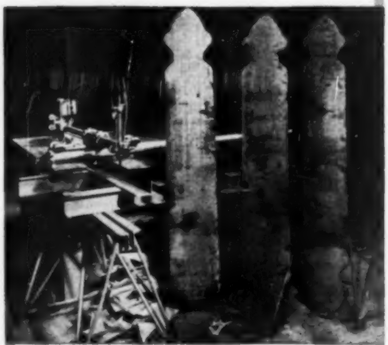
its portability, accuracy and shape cutting versatility make it a MUST for every metal working shop..."

Says Mr. J. C. Hustad, President
Hustad Company, Minneapolis, Minn.

Used for machine gas cutting of special structural shapes at Hustad, the Airco No. 3 Monograph has more than proved its ability to meet the demand for straight line, circle and bevel cutting, with an extremely high degree of accuracy.

Further, with a cutting area of 32 inches by 56 inches, it gives excellent results in cutting most any steel shape up to 8 inches thick . . . and a 6-foot 8-inch rail can be added, extending the cutting area indefinitely.

This NEW machine is the lowest priced machine of its type in the field (only $695, including a manual tracing device, torch, tip, tubular rail, hose and carrying case). Also, it is portable—the machine itself weighs but 110 lbs. and the tubular rail 35 lbs. The entire unit is packed in a carrying case which can be conveniently handled by two men.



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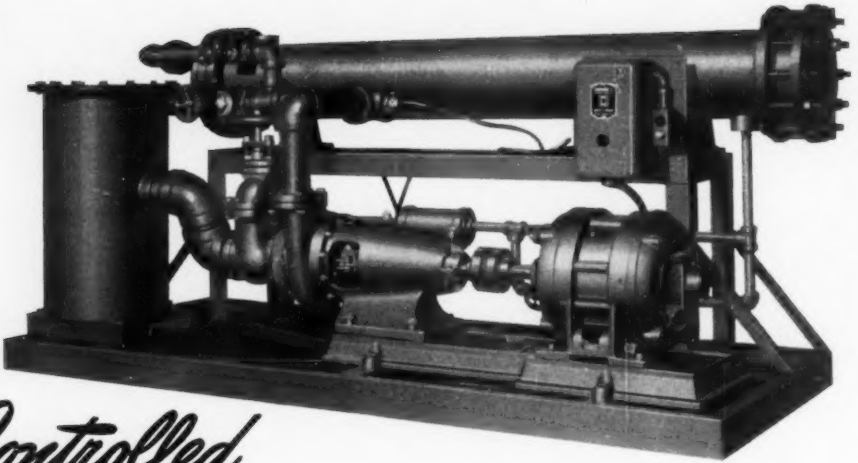

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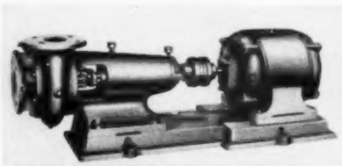

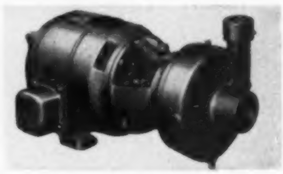

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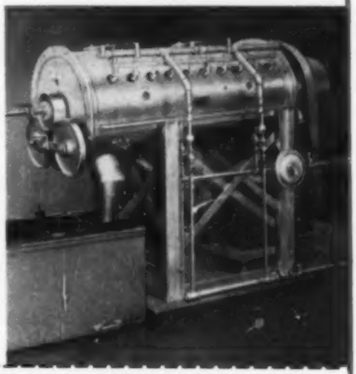

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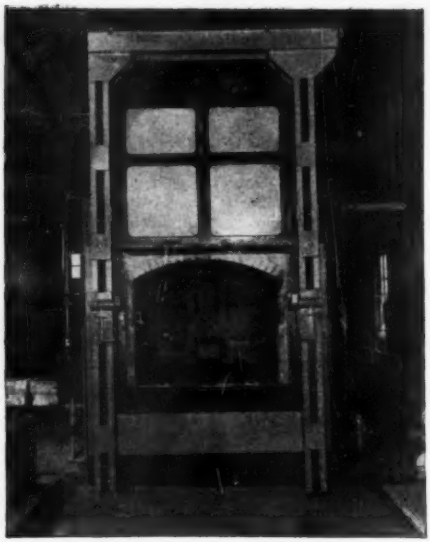

The hearth and side tile of this furnace, built by the Drever Company of Philadelphia, Pa., are made of CARBOFRAX silicon carbide tile. This is a single-end, under-fired furnace used for annealing, forming and general-purpose heat treating.

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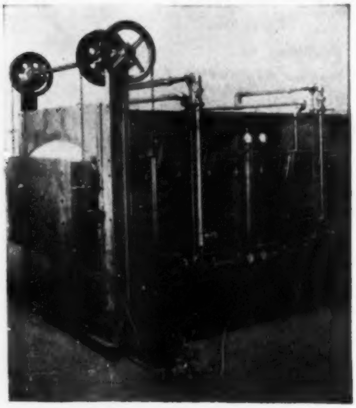

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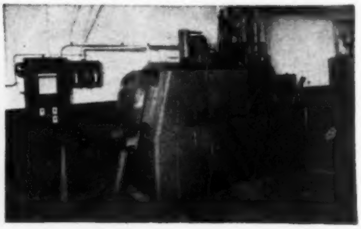

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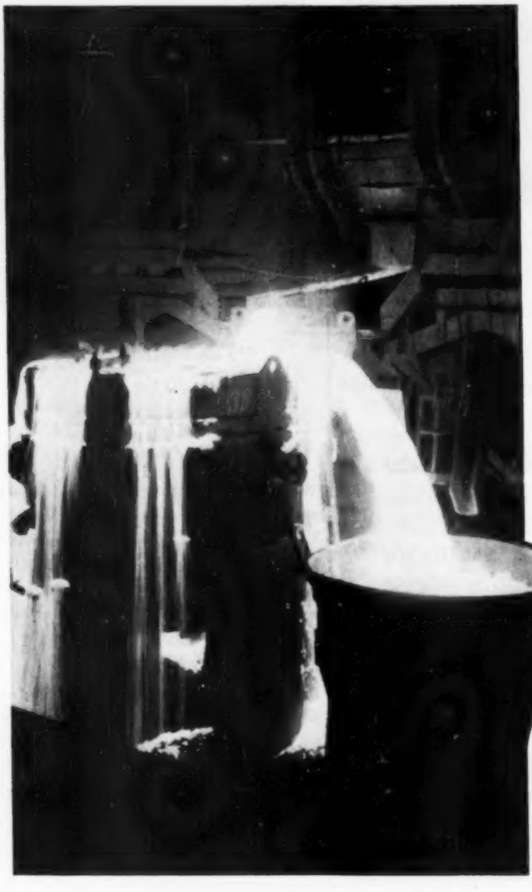

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January, 1951

Volume 59, No. 1

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Metal Progress

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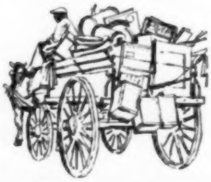
The role of Scrap in Steel Making



One of the most important raw materials in steelmaking . . . one frequently underrated by the casual observer . . . is iron and steel scrap. With over 90% of all the steel in the U. S. being made by the open hearth process, the scrap used by steel producers totals approximately 50,000,000 tons each year.

The open hearth method of steel production is geared to a pig iron scrap consumption ratio of roughly 50-50. This is to the final advantage of the steel user, since a large scrap diet in steelmaking results in a number of benefits: (a) steel is made faster (since scrap has already been "refined" once before, the "melt" time in the open hearth is decreased); (b) vital raw materials are conserved (it takes almost 4 tons of iron ore, coal and limestone to make a ton of pig iron); (c) unless scrap prices are abnormally high, the price of steel is cheaper; (d) steel is of higher quality (since scrap has already undergone one refining process); (e) transportation facilities, instead of being used for the additional raw materials otherwise required, can be released for other uses; (f) steel mill capacities can be expanded more readily with less emphasis on the blast furnace and more on open hearths and rolling mills.

About two-thirds of the scrap consumed in making steel comes from the steel mills themselves. Crop ends and sheared edges move quickly back to the open hearth shop. The remaining third, flowing to the mills largely through the 6,500 scrap dealers in the U.S., comes from the wastage in metal working plants ("production" scrap), auto graveyards, old building, bridge and ship wrecking projects, railroads (worn rails, freight cars, etc.), neighborhood junk peddlers.

The scrap dealers must sort the scrap so that the undesirables are eliminated, the alloys segregated and the right kinds of scrap can be delivered in large tonnages to the mills for most efficient steelmaking practice.

Today, with steel production at record peaks and with capacity continually expanding, it is more important than ever to keep scrap flowing back to the steel mills from *every* source. Everyone waiting for steel can help himself by assisting the movement of his scrap through his regular channels.

THE SCRAP CYCLE

Volume 59
1951

Ernest E. Thum
Editor

Metal Progress

Critical Points

By the Editor

Subject: Substitutions

WELL, here is where we came in! Need for record-breaking metallurgical production; shortages clutching from nearly all directions. World War II all over again, so it wouldn't hurt any to take an honest look at the probabilities and the possibilities.

Fundamentally, the civilization we wish to preserve is based on labor-saving and man-preserving devices, and these devices depend on iron and its alloys of steel. Basic, then, are six things: Iron ore, fuel (power), manganese, plant, labor, transportation. In all but one of these we are substantially self-sufficient in this Western Hemisphere, but one wonders how we could make, year after year, those 100 million tons of common steel — ship plate, pipe, barbed wire, drums and cans, rails and railroad cars — if our overseas supplies of essential manganese were slowly strangled. Even in iron ore, some good strategic planning on the highest level will be necessary to assure our absolutely necessary needs for the next 20 years — the two dangerous decades. Would it be better to expend the necessary treasure for a canalized St. Lawrence to bring in rich Labrador ore, or for huge concentrators to beneficiate the low-grade Minnesota taconites?

How about alloy steel?

In the early 1940's, much concern was felt (and rightly so) over the lack of other metals required for ten to twelve million tons of alloy steel yearly for such strong, tough items as tools, cylinder blocks, cranks, axles, guns, projectiles, armor. Of nickel and molybdenum we have large resources in North America (although there are many other pressing needs for nickel); of chromium, vanadium, tungsten, cobalt, we were short then and will be. To eke out the metal available, "National Emergency Steels" were formulated, some 120 of them, primarily with the idea that alloy in return scrap would be formulated into "triple-alloy steels", none higher than about 1%. The idea was such a good one that 40 of them are retained in the standard A.I.S.I. specifications. However, it should be remembered that the best we could do with N.E. steels in wartime was to cut the gross nickel requirements for alloy steels in half at the expense of doubling the molybdenum, increasing the manganese, and without reducing much the amount of chromium — that most strategic and critical element.

This having been done in the 1940's, what more can we do in the 1950's?

The one thing that certainly can be done is to work the principle, basic to the National Emergency steels, to the utmost — that is, the idea of selecting metals according to required properties rather than by arbitrary specification — thus: Choose lean alloy steels by their hardenability rather than by their chemistry. Here we can thank the shortages of World War II for a very great accomplishment. About 70 "H" steels are now standard and can be bought to guaranteed hardenability, ranging from quite shallow to very deep. Even if there is no price differential, patriotism requires the manufacture and use of that steel *containing minimum alloy* which can be hardened (strengthened by heat

treatment) sufficiently for the required duty. In many instances this will require a salutary re-examination of design and manufacturing processes — in other words, prejudice and habit must be replaced with brains and ingenuity. The metallurgical principles and methods of application are already well substantiated.

One might then ask, "What can be done even further to conserve scarce alloying metals?" Stated in another way this question means: "What elements are available which are not used in steel but which increase hardening power?" Boron immediately comes to mind. Boron is among the commonest of chemical elements. A small fraction of one per cent increases the hardenability of carbon and medium-manganese steels very considerably. Most of the facts concerning its use in steel have been on the record for a good many years, most producers have made some of it in full-sized heats, but no steel company has yet shown much interest in promoting boron-treated steels, nor has any large consuming group shown much interest in demanding them. However, it would appear to be quite suitable for a multitude of small parts where its improved hardenability is desirable.

Whether systematic research would discover some other element which would intensify the quenching action is questionable from a look at the periodic system. Boron, carbon and nitrogen are neighbors in the first series, and all are good hardeners. There are no other elements in similar places in the periodic sequence (except titanium) which might have similar action and which are at all common. Of course, the arm-chair metallurgist might suggest the widest use of nitrogen or phosphorus or even titanium, but the practicing metallurgist seems quite allergic to these elements in his common steels. (*Low*-carbon ferrotitanium, by the way, could replace most of the manganese in sheet, plate, structural and rail steel, if cost were no consideration.)

Summarizing the probabilities then, alloy conservation demands the use of the Jominy hardenability test and all that it implies to the very limit in selecting a commercial steel. A candid reappraisal of the carbon-boron, high phosphorus, and the titanium-bearing steels is also in order.

Of course, this whole matter of substitution by no means stops with iron and steel and alloy steels. Alternates for the very high alloys like stainless steel are also of importance. There is no question but that many applications needing corrosion resistance could be met with irons containing less chromium and nickel than the 18-8 that is so widely used. Save the chromium and nickel for the really tough assignments!

In this connection, attention naturally turns to the "glamor metals", titanium, molybdenum and zirconium. Forgeable ingots of titanium, at least, are in production weighing several hundred pounds, and are being used for services requiring stability and strength at temperature, such as gas turbine disks. However, these metals have been available for such a short time that their possibilities — either commercially pure or alloyed — are unknown. In a pinch they will be used if they can be produced. Nevertheless, in the long run each will be confined to nick-nacks and such special uses as in atomic energy reactors unless it were found to be able to do in a superlative way some of the things which our known tonnage alloys (like stainless steel, copper, brass, aluminum) cannot now do. For example, the principal and widespread medium which none of our present, common, and moderately expensive alloys can handle is sea water and its cousins, the salt brines of various concentrations and impurities. We are hopeful that titanium can do just that; that it will save us from a serious shortage in chromium. If it fulfills its early promise we can really use it in tonnage!

Price of these new metals is high, and since most costs depend on labor, high price means many man-hours, and in a real emergency labor is also scarce! What can be hoped for in tonnage operation? One is fairly safe in predicting that a pound of titanium will never be much cheaper than a pound of magnesium — for this reason: The present reduction process for titanium chloride requires magnesium metal (pound for pound). Even if any other reduction process is utilized, it takes nearly as much energy to dissociate titanium chloride as it does to dissociate magnesium chloride. Titanium, aluminum, magnesium — they're all power-consumers!

The problems of substitution do not even stop here with the age-old metals. There will be all sorts of necessities for economizing on copper and tin, and even zinc and lead, exactly as was necessary in the last war. Numberless substitutions were then made, but in almost every case the old metal was put back to work as soon as restrictions were lifted. The important exception is electrolytic tin-plate, which saves at least half the tin required by the ancient hot-dip process. Tin for solders, bearings and bronzes is certain to be scarce. There is *no* tin mined in North America; our sources are far-distant Malaya and Bolivia. As to the

rest of the nonferrous metals — copper, zinc, lead — the best we can do at the outset of today's emergency is to dust off the wartime alternates of the 1940's and put them back into the less exacting services.

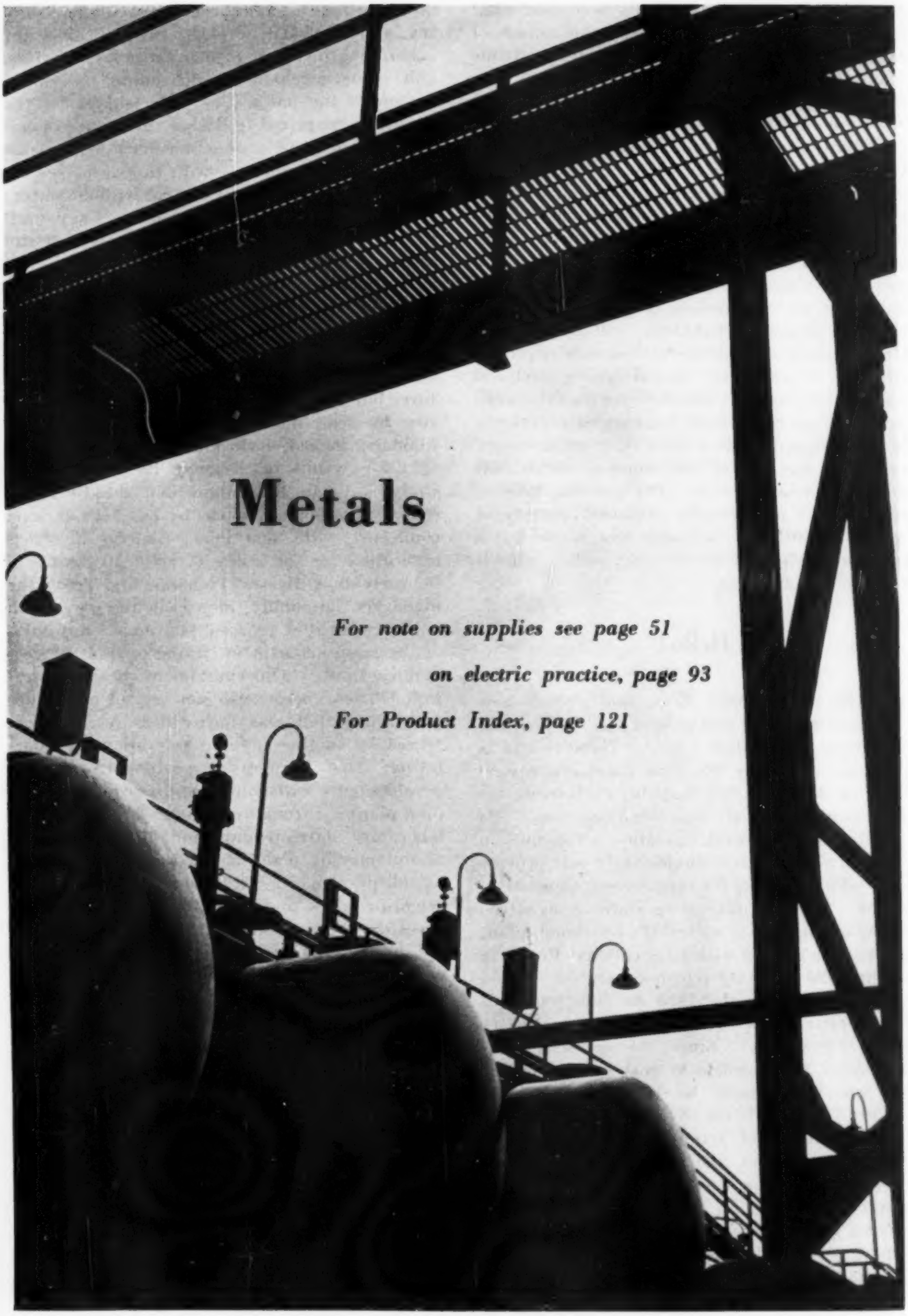
From this dark picture, turn to a brighter side. In aluminum and magnesium we are vastly better off than in 1940. Specifically, we can make six times as much aluminum (650,000 tons) and 20 times as much magnesium (125,000 tons), and neither figure includes Canada's large capacity. Expansion of either will wait on a new large source of electric power, yet here, in aluminum and magnesium, despite their demand for uses requiring lightness, will be found a real supplement to alloy steel for uses requiring strength, to copper for uses requiring electrical conductivity, and to chromium for uses demanding corrosion resistance. Leaning on experience in the last war, it is known that an increased supply of any one of the common metals will ease the whole situation. The question then is, what metals now can be produced quickly in greater quantities? Of course iron is one, but a great hope also lies in the light metals, aluminum and magnesium.

Hello!

THERE ARE SOME 35 million phones now installed in the Bell system and this number is growing two million a year. These two facts are responsible for Western Electric's newest plant in suburban Indianapolis, exclusively for the manufacture of the telephone sets. Its capacity on 40-hr. week operation is two million sets per year; partial double-shift will provide some additional sets for replacement in modernization. Another interesting statistic given the Editor during a tour with G. F. Raymond, plant manager, is packed with implications: Price tag on the 1920 standard telephone set was $10.53 (pre-war dollars); the 1950 set complete with dial mechanism is $11.30 and it's a far better set in every way! Since the material costs *something*, this miracle in cost control means that operations must be mechanized to the highest degree. This is obvious even to a casual observer: Acres of screw machines, miles of overhead conveyers, aisle after aisle of benches where young women, elbow to elbow, perform simple operations on subassemblies slowly passing by on continuous belts. Inspection is simplified by statistical control (many of whose principles, indeed, were developed by scientists in Bell Telephone Laboratories), the use of mechanical devices for accurate gaging and sorting, and electrical or electronic indicators for accurate adjustment of bell ringers, contactors, and other mechanisms depending on elastic flexion of the parts. . . . One marvels at the prescience required to design this entire operation, this intricate production machine, huge as it is — 900 ft. square — with proper places for 6000 people to work, rest and eat without getting into each other's hair. One marvels, I say, until he reflects that prescience explains it if it can be written with a hyphen: pre-science. Not only the telephone has been under scientific study for 50 years, but the proper method of making the set has also been under constant and intensive study. The Indianapolis lay-out did not spring, full panoplied from the brow of Jove, but rather is an oak that grows slowly, year by year, more and more complete. One wonders, indeed, how much the present cost ($11.30) would be *without* the accumulated study. . . . In this connection, the Editor is reminded of some remarks by Zay Jeffries, long connected with Nela Park, General Electric's institution for the study of artificial light. In the early days, Messrs. Tremaine and Terry, the managers, gradually increased the research budget, year after year, in its proportion to sales of the lamp department, trying to find the economical limit. "This experiment was a failure," said Jeffries, "because they never got to a figure which they felt was unjustified by its direct return." Another of his observations is interesting: That in many important industrial developments with which he is acquainted the pilot plant cost roughly 15 times as much as the laboratory development, and the commercial manufacturing plant about 15 times as much as the pilot plant. Stated in other words, the scientific work underlying a new product can be estimated at about one half of one per cent of the manufacturing plant's cost. Not an extravagant burden, as Messrs. Tremaine and Terry also discovered!

Help!

SINCE FALL, the American Friends Service Committee has shipped 135,000 articles of winter clothing and blankets to needy human beings in Germany, Austria, France, Japan, and Korea. Unlimited numbers are still urgently required. Please write to the Friends at 20 South 12th St., Philadelphia 7, for shipping directions to their nearest warehouse or collecting center.



Metals

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on electric practice, page 93

For Product Index, page 121

By Harry W. McQuaid
Consultant
Cleveland, Ohio

Ten Years in Steel

THE STEEL INDUSTRY, like other industries which in time of war are directly connected with the supply of military goods, was operated at high pressure from 1940 to 1950. The alloy steel tonnage needed for aircraft, ammunition, guns and transportation equipment, added to the permissible nonmilitary production, was sufficient to insure full employment of all production facilities and personnel. To the usual carbon steel grades was added a tremendous tonnage for the shipbuilding program; it alone was sufficient to keep the pressure high for production. At the end of the war the great drop in production, expected with so much certainty by the less optimistic leaders of the industry, failed to appear and pressure for high production has continued right up to this moment (August 1950).

New production records have therefore been reached at intervals since 1939, and this has resulted in a strong sellers' market with the principal accent on delivery. Under such conditions technical progress is always limited, and notable developments in practice or product are seldom made. Most of the pressure is put on additional facilities rather than on modernization of the old or obsolete — except in a few plants where the effort is made at all times to keep production costs down and production rates up.

While the steel industry's earnings have been relatively good, they have not been at all unusual compared to others — such as, for instance, the automotive industry. The past 10 years saw the semi-integrated producers retain their leading position, considering return on invested capital and earnings per ton of ingots. The returns on investment of the large, fully-integrated steel producer improved at a higher rate than the semi-integrated plant, which is to be expected in times of full production and good prices. Having come through the depression decade, 1930 to 1940, where returns were low and competition high, and where the well-run semi-integrated plant is at an advantage, the fully-integrated large steel producers were very much in need of improved financial returns.

Ore Supplies — The continued operation of the steel mills at full capacity depleted the reserves of high-grade iron ore in Minnesota to the point where the end is now in sight. This has stimulated interest in new sources of iron ore in Africa, in South America and in Canada. The increased cost of American rail transportation, due to higher freight rates in the past 10 years, has already had its effect on increasing the cost of pig iron and, with much of our iron ore coming in by boats to our eastern and southern seacoasts, it is obvious that serious consideration will be given to the building of steel plants along these coasts. However, intensive work is somewhat belatedly being done on the concentration of lower grade ores which exist in almost unlimited quantities in Minnesota, and the next 10 years should see some results of this work.

Due to the very lean financial years of the 1930-1940 period the very minimum of money was spent on plant improvements; during the war the difficulty of getting new equipment and the high pressure for production on any and all equipment further prevented any great modernization programs. After the war ended, the opinion of many of the steel plant executives that a severe recession was just around the corner postponed the buying of badly needed new equipment and the "earmarking" of funds until prices were lower. We therefore find most of the steel industry entering the next decade with (generally speaking) outmoded equipment of relatively high operating cost.

Pig Iron and Scrap

While there has been no startling technical progress in the steel industry during the 1940-1950 period, there have been some spec-

tacular changes. Coal miners' wages and benefits have pushed the price of coke up to the point where the cost of pig iron has seriously affected the economics of the openhearth and the foundry. The high cost of both coke and ore has emphasized greatly the need for improving the economics of the blast furnace. Higher top pressures have been used at the Republic Steel Corp. as a step in this direction, but so far there has been no swing toward this practice by others.

The use of oxygen-enriched blast was hailed as a revolutionary possibility in cutting iron costs — but this seems to have reached a state of extreme quiescence. The use of natural gas, or combinations of natural gas and tonnage oxygen, would seem to be a natural approach to reducing the coke consumption in the blast furnace, especially in the areas where natural gas is plentiful and relatively cheap as compared to coke.*

Scrap steel has changed from a dependable and stable item to a most expensive, unstable basic raw material. This has made the operation of the openhearth and electric furnaces a nightmare of economic uncertainty. Instability in scrap price is due primarily to a very close balance between supply and demand, and it would seem that the only near-by cure is the development of a lower cost, more stable substitute.

The recent proposals for high-temperature cracking units for natural gas which make hydrogen (and carbon black) at an extremely low cost may be one answer. Lightly briquetted, finely divided magnetite concentrates can be completely reduced at relatively low temperature by hydrogen. This seems to offer an almost pure iron charge for the electric furnace or openhearth, and be the answer to the recurring proposals for "direct reduction" of iron ore.

Economics of Plant Location

In addition to high costs of coke, ore and scrap at the source, the increased freight rates have contributed a large part to the cost of these materials at the furnace. Consequently the location of a plant in relation to the necessary raw materials has become of greater importance than ever before.

The location of a steel plant in relation to its markets has assumed a position of much greater importance due to the abolition of the basing point practice of prewar years. Now the customer pays all the freight from the mill and not from the nearest basing point. In a strong sellers' market, such as we have had for 10 years, the elimination of the basing point arrangement has really benefited the steel industry because freight formerly paid by the steel producer is now paid by the customer.

If a strong buyers' market does develop, however, the lack of a basing point arrangement will act as a severe handicap to plants even a little distant from their markets, and will benefit the near-by plants. Historically, the steel industry was located primarily by accessibility to raw materials or to labor markets; in a strong buyers' market some of our largest steelmaking centers will be severely penalized.

Technical and Mechanical Improvements

The increased use of oxygen has been one of the important technical developments of the last decade, principally as an economical device for removing surface defects in hot rolled products. The scarfing torch has replaced most of the chipping chisels. Oxygen has also entered the melting department as another valuable tool to increase the rate of melting and of carbon reduction.

As is usual in industry, most of the recent research has been in the field of raw materials and supplies, and has been due to the suppliers' efforts to improve their position in the industry. This has resulted in improved refractories, auxiliary equipment, sinter plants, electric furnace and openhearth controls, and general working conditions. Major production equipment has not been markedly changed during the last 10 years of high production. Many plants are still operating billet and bar mills which were installed more than 25 years ago and which have a relatively high production cost as compared to modern, semiautomatic, continuous mills.

Basic design of openhearth and blast furnace has changed but slightly, except to increase in size. The electric furnace has definitely become a top-charged unit; the door-charged furnace, no matter how recently installed, is obsolete as far as maximum production and low operating costs are concerned. The last decade also saw a marked increase in the size of electric transformers in the attempt to increase the production rate per man-hour. This has, with the top charging, improved the economics of the electric furnace greatly as compared to the openhearth, but the high price of scrap has prevented the electrics from really coming into their own in tonnage steel.

*Editor's Footnote — P. E. Cavanagh has discussed, interestingly and at length, the problems connected with improved blast furnace practice and reduced coke consumption in *Metal Progress* for April and May.

While the steel industry is a relatively slow-moving industry as far as process and product development are concerned, it *does* move! Some of the stirrings of the past decade will probably blossom into full practice in the next. These include continuous casting, so actively worked on by the Babcock and Wilcox Co. for billet production. Since continuous casting is more applicable to slab-like shapes (because of their higher proportion of cooling surface to mass or cross sectional area) it would be expected that it is in this field that continuous casting will have its greatest success. The work done by Goss and others in this field already indicates its possibilities.

The successful application of the Sendzimir type of cold mill to very light gage strip was one recent development which promises to increase widely. The Sendzimir hot mill, while still very much in the development stage, indicates that something new is beginning to stir which may upset the present whole conception of hot rolling.

Hot extrusion of steel is also an interesting possibility which may (with its newly developed practice of lubricating the die with molten glass) do in steel what it has already done in the nonferrous field.

Changes in Alloy Steels

Triple-alloy steels, low in chromium, nickel, and molybdenum, appeared during the wartime shortage of these alloys, and have resulted in the present A.I.S.I. 8600, 8700 and 9700 series. This trend has been important to the steelmaker because it minimizes the problem of residual elements so hard to control in grades containing but one or two alloying elements. It was also important to the user because it assured him of metal more uniform in its reaction to heat treatment, and generally at a lower cost than many of the single or double-element alloy grades which they replaced. They were of special interest to those industries such as the automotive, where relatively shallow hardening was desired in combination with high surface properties.

This growing use of low-alloy combinations was associated with a decrease in the general use of the steels higher in nickel, except possibly in the nickel-molybdenum grades. Nickel is likely to increase, however, as a curative for certain undesirable effects of the "tramp alloys".

Thus: The type of alloy steel most commonly in use has an effect on steel melting because of its effect on the type of return scrap available. Some elements (such as nickel, copper, tin, and molybdenum) pass from scrap to the molten steel bath with little if any loss and are found in the finished steel, whether specified or not. This means that there will be a continuing increase in the residuals of nickel, copper, tin, molybdenum and even arsenic. Copper has an adverse effect on surface in hot working unless enough nickel is present to prevent it. Small amounts of tin are detrimental, especially intensifying the adverse effect of copper. Arsenic acts in a manner similar to copper and intensifies to some degree its adverse effects. Thus, nickel will probably be needed in most steels to offset these bad effects of copper on surface conditioning. Consequently, the nickel-molybdenum combination with manganese and chromium promises to be tomorrow's common alloy.

The Metallurgist's Future

The place of the metallurgist in the steel industry improved somewhat during the past decade. The increasing use of detailed specifications by the customer on his orders has required a high degree of metallurgical supervision in the writing up, scheduling and inspection of those orders through the steel plant. The accent on wartime grades requiring special handling and inspection largely increased the demand for men with a high degree of metallurgical training. Many more technical contacts were necessary with the steel users, so the demand for field contact metallurgical engineers increased correspondingly. Due to the great need for operating metallurgists in the plant, most of the sales metallurgical work was reduced to technical contacts only, and every possible man was used in connection with production.

While the last 10 years have shown an improvement in the standing of the metallurgically trained men in the steel industry, there is yet much to be desired. Before the relative financial standing of the metallurgical profession in the steel industry can be definitely improved it will be necessary for the average metallurgist to be much closer to the everyday economics of the steel plant and to be considered an important factor in improving not only quality, but processes and production costs as well. Slow as most of the units of the steel industry are to move, they should eventually recognize the value of the skilled, metallurgically trained man if he becomes associated in the mind of the management with improved processes and lower costs. The last decade saw some improvement in this direction, but much still remains to be accomplished.

By Richard E. Paret
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Stainless Is Growing Apace

THE NATION'S CAPACITY to produce stainless steel is expanding vigorously. As a matter of fact, production of ingots has more than doubled during the last decade.

Producers of stainless have foreseen an increasing market, and they have continually enlarged their facilities to keep pace with the demand. This market has been highly competitive, and the attempt to gain and keep a share of it has been marked by aggressive selling. Indeed, the story of development, manufacturing improvements, engineered applications, and consumer education in the stainless steel industry follows the typical American free-enterprise pattern.

Like many other industrial successes which have improved our world, the growth of stainless steel's importance has been based on four main ingredients — technical development, competitive manufacture, wide dissemination of the special fabrication techniques, and the spreading of information about the advantages to be gained in using the product.

The balance between wartime and peacetime uses of stainless steels can be seen in the production tonnages tabulated at the right. During the first half of the last decade, stainless output was more than doubled to meet war needs. Both in fighting machines and in the explosives, petroleum, and rubber industries that back them up — to say nothing of the atomic energy project — there were pressing demands for corrosion resisting alloys. Industrial demands have grown so large in the postwar years as to absorb easily the available tonnage. The gain has therefore been a permanent one.

The qualities of high strength at elevated temperatures, stability, toughness and resistance to corrosive deterioration are of vital importance in military applications. As a typical example, the exhaust manifolds for conventional aircraft engines require the properties that stainless offers. Even more, many vital parts of jet engines demand high-temperature strength coupled with corrosion and scaling resistance. This one field of application alone points toward tremendous tonnages of stainless in an all-out war program.

Joints in armor plate are welded with stainless steel electrodes to obtain the necessary ductility to avoid cracking during welding, and countless other applications with stringent requirements add to the total needs of a military economy.

In the future, we may anticipate far wider use of stainless steel for equipment and fixtures employed in development of nuclear energy for peaceful uses than for the production of atomic weapons.

From the large number and the relatively specialized nature of stainless applications in World War II, it would have been natural to look for a pronounced drop in production and utilization when hostilities were terminated. The statistics show that this did not occur.

U. S. Ingot Production of Stainless Steel

Year	Production (Net Tons)
1939	180,000
1940	250,000
1941	372,000
1942	341,000
1943	457,000
1944	477,000
1945	543,000
1946	550,000
1947	520,000
1948	617,000
1949	455,000
1950	400,000*

*For first six months. Current production has run steadily near the rate of 800,000 tons per year.

The reasons why more stainless was produced and used in the second half of the last decade — instead of less — are many and complex. Perhaps most important is the fact that a great deal of the metal went into *essential* industries during both periods. All the chemical processing, oil refining, heat treating, paper and pulp, textile, and food preparation equipment that has been made of stainless has served to establish the mate-

rial in these industries very firmly. The lessons of wartime production often formed a basis for peacetime expansion. It resulted, therefore, that peacetime demands easily absorbed the expanded producing capacity of World War II, then required further increases.

The automobile industry uses substantial tonnages of strip for formed trim — permanently bright. Railroads have followed suit.

The nickel-chromium types of stainless have also found their way into many new applications throughout the refining, processing and manufacturing industries. A great deal has gone into utensils and food handling equipment. From preparation, packaging and transportation down to kitchen equipment, stainless has played a most important and satisfactory role.

Architectural uses of stainless, though still far short of their ultimate potential, are just beginning to attain significance. Electronics equipment is absorbing substantial quantities in video tubes.

Prospects in Near Future

We are now faced with a dual responsibility in apportioning our energies and materials. The first responsibility must be that of military adequacy. The second, which the first is designed to safeguard, is to promote the welfare of our industrial and consumer economy. In the long run, we have found that this second effort tends, reciprocally, to safeguard the nation's military potential.

World conditions that force tensions on the military side bring with them a keen set of dilemmas and the need for shrewd compromise.

If we should assume, for a rough appraisal, that the wartime plant expansion was substantially completed in 1943 and that the annual stainless ingot production rate in 1944 and 1945 — say 500,000 tons — represented a predominantly military outlay, then, in the same approximate way, we might then say that the 1950 rate of 800,000 tons annually is an indication of the present peacetime demand. Such assumptions might set something like 1,300,000 tons as our annual stainless steel budget for a near-by "guns-and-butter" economy.

However, this line of reasoning is false on several counts. In the first place, it calls for a larger jump in production than our manufacturing resources would be able to stand immediately without sacrificing some other equally important effort. Second, the same is true for the essential ingredients, chromium and nickel. Third, the *needs* for stainless steel, in an emergency, can probably be kept within far lower limits.

The portion of the production now going into equipment for basic industry would surely be assigned to the same use under a war economy. Increases might even be expected, but only as rapidly as other factors in the production and use of equipment containing stainless can be brought into step.

Again, a great deal is now going into applications hardly considered essential. The normal consumption for products like automobile trim, office appliances, household utensils, sporting goods and store-front trim has amounted to between one fourth and one third of the total shipments. The producing capacity represented by this expendable portion of our usual consumption can be diverted to war uses whenever necessary.

Production Factors

While the over-all capacity to produce stainless has increased steadily, and this trend can be expected to continue, the relationship of stainless production to our entire steelmaking economy is so intimate that any immediate or radical spurts are unlikely.

In a period when all commodities are scarce, and when prime power is also limited, there is less opportunity to bolster a need than there would be in the event of an isolated shortage. In order to appraise the position

Surveillance Antenna of Radar at Los Angeles Airport Typifies Upsurging New Use for Stainless in Video, Radar and Oscilloscope Tubes

of the stainless steel industry, one must review all the factors that influence its production and see how they affect other needs.

Stainless steel capacity shares with almost everything else its primary requirement. This is power. Mining and reduction of ores, melting, rolling and fabrication — all take power. Consequently, American power sources have been and are being built up substantially. If radical increases in all sorts of industrial activity should overtake the power supply, the quota for stainless steel production would, of course, be apportioned according to the need for the material — either by the law of supply and demand or by rationing.

Shortages of manpower, transportation, and such basic commodities as building materials, steel and electrical equipment would also impose limitations if a general expansion of facilities were attempted in wartime.

More specifically, stainless production is directly affected by available supplies of chromium and nickel.

Chromium has been supplied to the industry at a rate adequate to support the production rate of 800,000 tons of stainless steel annually. Its availability for stainless ingot appears to depend mainly on whether diversion of ferrochromium to other uses should become necessary — for example, for making heat resistant castings, for other high alloys — or, for that matter, to the A.I.S.I. alloy steels. Any decrease in the amount of chromium on the market due to demands of national stockpiling — or increases due to withdrawals from stockpiles — would cause corresponding fluctuations of the visible supply.

Nickel, also, is being mined in Canada at maximum rate of 250,000,000 lb. per yr., and the U. S. government is reactivating the Cuban mines that can produce about one tenth as much. It is currently being supplied at a sufficient rate to support present production of stainless steel. However, available nickel is subject to many other demands. Stainless shares nickel with the low-alloy steels and alloy cast iron, toolsteels, the superalloys, and primary nickel products. Furthermore, the principal mines in Canada must take care of the needs of other friendly nations, and belated stockpiling. When other needs take precedence, as they have recently, stainless steel output must suffer.

Supplies of columbium have already become critical. However, this element in its pure form is not the only means of stabilizing stainless against carbide precipitation. The ferrocolumbium formerly used always contained a percentage of an associated element, tantalum, and research has indicated that a considerably higher proportion of tantalum will be satisfactory for most uses. This will stretch the columbium supply by utilizing available ores high in tantalum. Use of the columbium-tantalum combination may require some modifications of existing mill practices. It is also usable in some of the "superalloys" — indications are that it is even superior for extra-high temperatures.

Fortunately titanium, which is relatively plentiful, offers an alternative to the use of columbium in many stabilized applications. This situation was canvassed at length in a notable series of articles in *Metal Progress* for last November. Improved extra-low-carbon stainless steels also help ease the situation with regard to the stabilized types. Lastly, it is certain that many times the stabilized alloys are specified when the conditions of use are not severe enough to warrant them.

Mill Equipment — Electric furnaces capable of melting stainless are readily available. Unless substantial numbers should be diverted to other types of alloys, melting capacity need not entail a bottleneck in the near future.

Ingot preparation and rolling capacity have recently been augmented by several new modern mills, expressly designed for handling stainless steel. With power systems, equipment and controls arranged for efficient rolling, such plants are an especially valuable addition to our capacity.

Finishing equipment for sheets and plates has been more than adequate. Furthermore, should the bulk of any military expansion revolve around applications of high-temperature stainless, the need for *polished* sheets and plates should not increase too suddenly to be handled adequately.

It is apparent that the over-all picture of stainless capacity is one of interdependent limitations. Whatever rate of production becomes necessary will have to be achieved in harmony with other requirements of American industry and the economy of the country in general.

Economy in Use

There are ways, however, in which the nation's supply of stainless is being effectively extended today. They grow out of more efficient utilization of this remarkable material by designers, fabricators and users. Producers are being more resourceful in accumulating and utilizing nickel-bearing scrap.

Designers today are increasingly more competent at applying the stainless steels where they

will do the most good. With help from the producers' metallurgists, they can work out functional concepts in terms of reliable performance, fabricating and other technical data. This means less waste and fewer replacements.

Users have learned how to care for stainless steel. They get the full measure of service from expensive equipment. Better maintenance, in itself, is a substantial conservation measure.

Developments in the steel industry have enhanced our resources in two general ways: One has been a better product that will go further in its intended use. The other is a general advance, resulting in an over-all saving of time, effort and raw materials, and thus stretches our available supplies.

For a better product, some outstanding advances have come in rolling techniques. The introduction of small, backed-up rolls in equipment like the Sendzimir mill has brought thin, close-tolerance sheets and strip into economical production. Close tolerances on thickness and camber save material. The availability of extremely thin stock approaches the ideal — that the *surface* of stainless is all that is required in many applications.

Current laboratory work which shows great promise, but which is not yet incorporated into commercial practice, involves cold working the nickel-chromium stainless steels at extremely low temperatures. It appears possible to obtain substantially increased strengths at no sacrifice of ductility. The process depends on the way the metal work hardens when it is rolled or drawn while in the temperature range of around -300° F. Any development of this nature has economic and practical limitations, such as the remaining problem of stiffness where deflection is a design factor. However, this type of research opens up new ways of expanding the usefulness of a given amount of material.

In the same vein, recent successes in hardening stainless steel cutlery by quenching at very low temperatures have contributed to the metallurgical art.

Formulation of special alloys for exacting applications has as its first effect an increase in the usefulness of the steel that is produced. At the same time, it may have stimulated new needs and new inroads on our present production. The perfection of stainless cones for television tubes is an example. This application, which we must anticipate would mean radar and oscilloscope tubes in war's emergency, represents a most useful technical advance combined with a significant new demand for material.

The progress that the stainless steel industry has made during the last ten years toward increasing yield has contributed an extra margin to our store of resources. By getting a higher yield per ingot-ton produced, we have, for practical purposes, augmented our producing facilities. Because it has saved time and materials throughout the production cycle, this has proved one of the most rewarding directions for activity.

Much of the improvement in yield has come out of improved melting procedures. The order of adding various parts of the charge, control of temperature and time intervals, and control of oxidation — all have received attention. For example, nickel oxide sinter, added primarily to supply the bulk of the nickel required, results in highly effective decarburization. It permits the use of higher carbon scrap, and saves valuable melting time by burning the carbon out more rapidly. The use of the oxygen lance in the melt for decarburization — a standardized procedure at present — has also promoted the general availability of extra-low-carbon 18-8. Ferrochromium can be supplied with 0.03% maximum carbon as another aid in this direction.

Extra-low-carbon Type 304 should be welcome on two counts, first for its improvement in the yield per ingot-ton and second as a conserver of columbium and titanium. Except in extremely high-temperature service or in especially corrodible environments, the extra-low-carbon alloys are an adequate replacement for the stabilized types. They are more readily workable in production, and can be turned out with substantially higher yield than the stabilized types. Consequently, this development ranks high as an aid to conservation and efficiency.

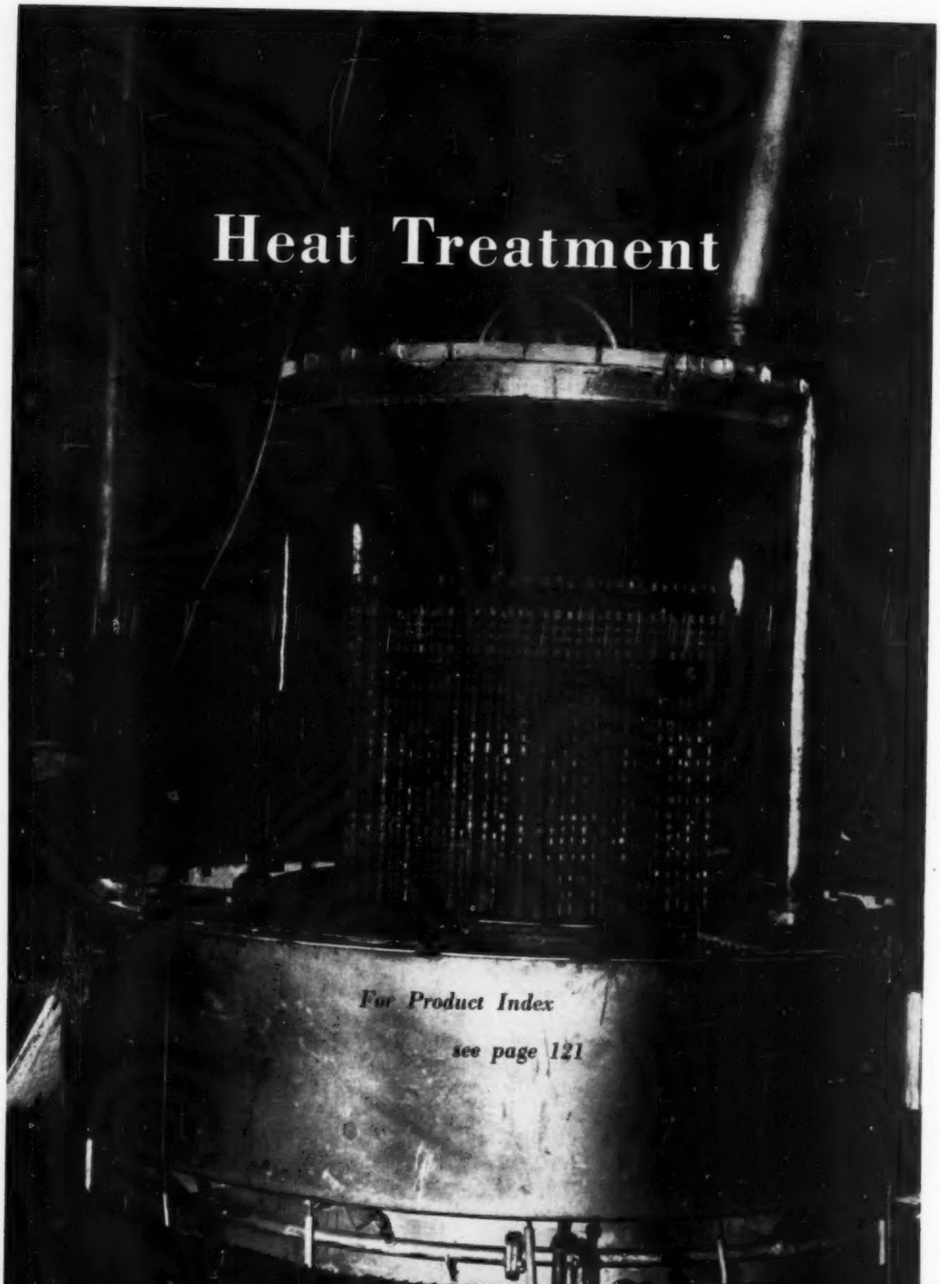
The extensive descaling required at stages between ingot and finished product has always required a great deal of time and effort. Electrolytic descaling gives a better product and higher yield; it removes the scale selectively, leaving clean metal, and it is far speedier than mechanical chipping, grinding or machining.

Summary

The stainless steel industry has a background of consistent accomplishment. A steady growth in production and a constant improvement in technology have laid a sound basis for future progress.

Whatever requirements the course of history may impose on our producing and engineering facilities, the stainless steel branch will certainly give a good account of itself.

Heat Treatment



For Product Index

see page 121

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Improvements in Furnaces and Methods for Heat Treatment

ANY EFFORT to prepare a brief review of improvements in the art (and possibly science) of heat treatment in the 1940-1950 decade causes pause at the very outset. So many excellent pieces of new equipment stream from American furnace builders that any selection of a single installation would be an invidious comparison, however unintentional. Similarly, difficulty would be faced in picking any trend as being the important thing to watch in the 1950-1960 decade, for undoubtedly a set of manufacturing conditions that make for optimum production at present in one shop or on one job will not exist elsewhere or in the future.

In this dilemma the safe escape is to discuss the *principles* underlying the art of heat treatment and furnace construction. When attention is turned in this direction, it becomes apparent that recent improvements have followed the correct application of scientific principles, and future advances will follow their more widespread understanding.

Correct heat treatment of metals is contingent upon many factors, due to the varied requirements of processed parts. The basic factors influencing the choice of equipment, however, are often restricted to a very few considerations such as optimum heat flow rates or the rate of chemical reactions at the metal's surface. Therefore, it seems quite opportune to attempt a discussion of trends in the industry from the viewpoint of these limiting factors, since, if our evaluations be correct, we may consider any past or future developments as expedient applications of fundamental principles.

Were a single quality to be chosen as particularly pertinent to rate problems of this nature, the choice would be potential, or driving force. As is well known, a difference in potential with reference to temperature causes a flow of heat, while a difference in *chemical* potential is necessary for the flow of matter. But the control of such transfer rates or flows is of primary importance in our processing. Consequently, we may well divide the discussion by considering first the heating processes and subsequently the problems of atmosphere control, using elementary processes to illustrate the importance of limiting factors. To the extent that these factors are favored, the operation of the process is improved.

Heating Processes — In the majority of heating problems for metals, the controlling factor is the rate at which heat may be transferred to the metal's surface, rather than the rate for conducting the heat within the metal itself. When the entire part is to be uniformly heated, and when no other qualifying conditions exist, heating rates for maximum efficiency may be readily given, particularly for the relatively high temperature processes — those above 1000° F. Here radiation is the predominant transfer factor, and the anomaly is presented that the hotter the piece must be, the greater is the furnace capacity per unit hearth area, even though the heat added per unit of metal weight also increases with temperature. This is due, of course, to the fact that radiation increases as the difference of the fourth powers of the temperatures of emitting and receiving surface.

Now this fact is effectually applied in furnace construction by the zoning principle; as applied

to the continuous furnace it is illustrated in Fig. 1. A minimum of two zones (or two relatively independent sections) is required for control. By far the greater amount of heat is transferred in the first or heating zone, where the temperature differential between the radiating wall and the metal surface is comparatively large. In contrast, the temperature-attainment zone is one of low heat input, furnace to work. The control setting for either zone may be that of the required final metal temperature with the following provisions: *(a)* The control point for the heating zone must be near the end of the section in the direction of stock travel, and *(b)* the rated hourly capacity in lb. per sq.ft. of hearth area must not be exceeded. For steel, the capacity ranges from 20 lb. per sq.ft. per hr. at 900° F. to 80 lb. per sq.ft. per hr. at 2150° F., as shown in Fig. 2. "Hearth area" is defined as that space which is uniformly covered by the charge.

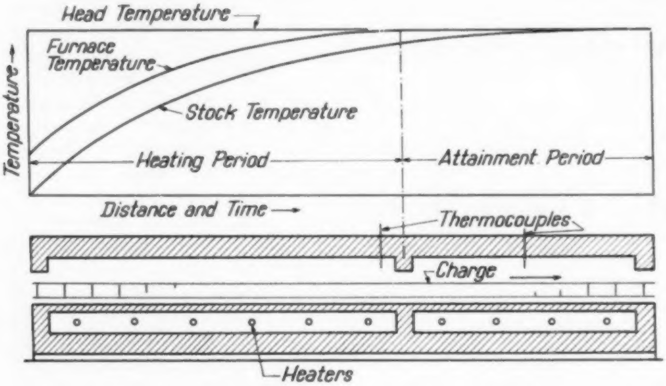


Fig. 1 — Sketch of Continuous Furnace (Below). Curves at top give approximate temperature relationships between radiating furnace wall and charge moving through

The problem is quite similar in mass loading with the batch-type unit, since the heat input rate again must decrease as the control temperature is approached. Figure 3 is for a recirculating pit-type furnace suitable for heating a dense charge of small parts to lower temperatures than are economical in equipment sketched in Fig. 1. (The charge is really dense, as its weight is over 40% of that of a solid piece of metal of the same over-all dimensions!) When the control couple (4) above the charge reaches 775° F. (Point *A* on the curve, or 75° below final temperature desired), the heat input is automatically reduced to about one third that used in the earlier heating period. The temperature of the entire charge then tends to equalize well below the process temperature, and the cycle has maximum efficiency and uniformity.

High-Head Heating — It is obvious from Fig. 2 that the time per cycle may be decreased below that described. Such short cycles may be termed "high-head heating". We find two very general divisions of this — first, where the entire part is to be uniformly heated, and second, where the heating is limited to certain sections of the part, or to quite restricted portions of a given section.

Heating of forging billets is a typical example of the first. Fast heating tends to decrease scaling and decarburization due to shortened times of exposure to reactive atmospheres. Capacity ratings exceeding five times those given in Fig. 2 may be attained with proper control when care is taken to expose all surfaces of the heated part. In general, the surface-volume relation-

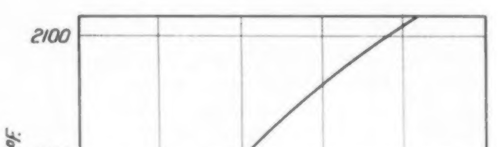


Fig. 2 — Relationships Between Temperature of Radiating Furnace Wall and Rated Capacity of Continuous Furnace, When Head Temperature (Fig. 1) Equals Temperature of Work at Discharge

ship of the part must also be uniform for this rate of heating. Fuel-fired units, designed for specific operations, as well as induction equipment at moderately high frequency, are finding many feasible applications in this field of high-head heating.

When the rate of heat transfer *to* the piece must be balanced with heat flow rates *within* the metal itself, a great variety of practices are to be expected, and every example will have its optimum set of requirements. Take for instance Fig. 4 on p. 66, which shows selectively hardened areas on a cam; a special machine and a propane-oxygen burner head have developed a closely controlled pattern. Another instance is a flywheel ring gear with medium carbon content. Its requirements are hardened teeth, and a limited hardness gradient to the unhardened back (Fig. 5). This may well be heated with a circular induction block (using high-frequency current) while the gear is rotating. After reaching correct temperature at the surface, it is dropped and held for a short time to level out the temperature, and the teeth are then quenched in a timed water spray to produce the treated section shown in Fig. 5. Again, on small sections which require moderate heat additions, a flame from the simple gas-air mixture may have interesting applications. Both

The author pays tribute to the American furnace builders and points out that existing automatic and semi-automatic devices, both for generating protective gases and for putting heat into metal parts, may be applied advantageously to a far greater extent than at present. A few concrete examples illustrate the general principles.

examples depend on properly engineered combustion principles and heat transfer factors.

Silver soldering of two quite different sheet metal sections is another illustration. Here the solder must be melted in such a manner that the joint between the plate and the pipe (Fig. 6) is properly filled. This means that heat must be accurately applied and distributed to the pipe and plate. The cap, of heat resisting alloy, affords this distribution; its tip extends into the pipe and vents normally to the pipe in line with the solder ring. Auxiliary venting through the shoulder of the cap proportions the heat transfer to the plate into which the pipe fits, and the upper portion of the cap including the tip remains at a fairly uniform temperature (approximately 1500° F.). The use of the cap, fitting closely as it does to the burner tip, demands a sharp, stable flame, since combustion must be complete in the restricted volume within the cap. The length of the burner tip and the clearance provided for the auxiliary pilot mixture are other important considerations, since enough heat must be provided to the mixture to stabilize the flame without unduly heating the tip proper, which would increase the velocity of flame propagation and cause backfire.

It may not be amiss to mention a means of cooling as an example of temperature control and heat distribution, for example, low-temperature baths of molten salts, in which large charges of heated parts are cooled.

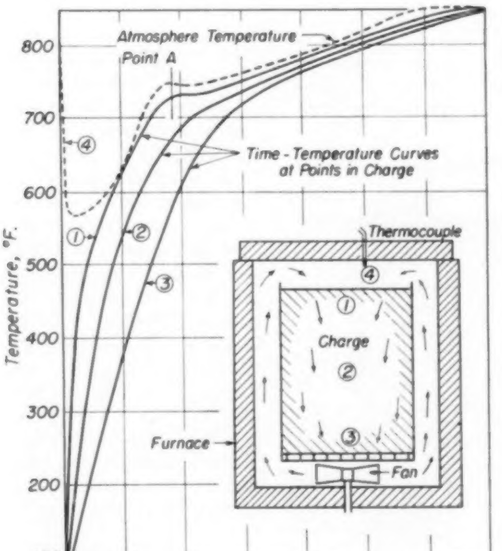


Fig. 3 — Time-Temperature Curves for Control Point (4) and for Three Points Within Closely Packed Charge of Small Bolts, Heated to 850° F. in Recirculating Pit-Type Furnace

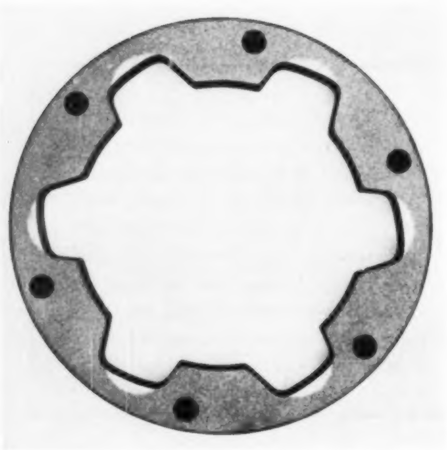


Fig. 4 — Hardness Pattern on Cam

The objective of the ensuing section will be to aid in recognizing the limiting factors in atmosphere processing.

Furnace Atmospheres

Perhaps the greatest impact of correct furnace atmospheres is found in the heat treatment of finished parts. Here an evaluation of the reactions which may occur at the face or surface is essential for a correct choice and control of the atmosphere. Ideally, only those reactions desired at the surface should be allowed to proceed in the work chamber; the atmosphere itself should be prepared outside the furnace proper.

For steels, the chemical potential and reaction capacity of the gas phase with respect to that of the solid is chiefly concerned with two elements, oxygen and carbon. A great number of gaseous compositions may be obtained in a practical manner by varying the ratio of air and hydrocarbons fed to the atmosphere generator — as is shown in Fig. 7, applying to methane. Many of these gas compositions have industrial application, and we may view them in the order of decreasing oxygen potential (and increasing carbon potential), which varies as the air decreases in the reactant mixture.

The products of complete combustion with the water content lowered by cooling (Line 1 in Fig. 7)

Fig. 5 — Portion of Flywheel Ring Gear, Sectioned and Etched to Show Hardened Surface Grading Into Unhardened Roots

Choosing air at moderate pressure as the safest and most economical coolant, manifolds are provided for the entering and effluent air. These manifolds are connected with steel tubes of moderate section and the tubes extend down the side of the bath, across and up the opposite wall, thus partially enclosing the space which receives the parts to be quenched. Here the limiting factor of heat transfer is not from the salt to the exterior pipe wall, but rather from the interior wall to the moving air. When this transfer factor is favored by providing a reasonable pressure drop between entrance and exit manifolds, the air will blow off at a temperature very close to that of the bath proper — a condition approaching maximum efficiency.

Necessity for atmosphere control in many heat treating operations is responsible for new methods of heat transfer and distribution, and we may expect many further improvements with expanding needs for improved atmospheres. Such demands have already accelerated the use of radiant-tube heating, and improvements in high-temperature recirculating fans — to mention two important adjuncts. In such devices it is important that the flow of the gases be accurately controlled, and this, in turn, requires that furnace structures be relatively airtight. Problems associated with proper seals and close fitting mechanisms operating at elevated temperatures need careful evaluation.

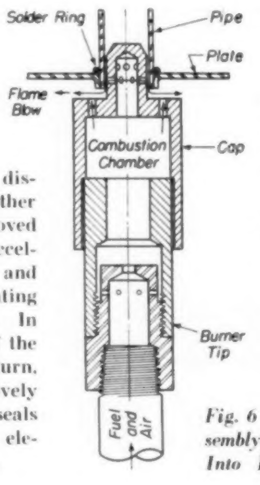
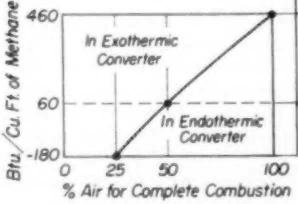


Fig. 6 — Burner and Cap Assembly for Silver Soldering Pipe Into Flanged Hole in Plate

may be usefully applied in tempering operations below 1200° F. Using a well-sealed chamber, and a flow sufficient to exclude air, a "controlled oxide" finish which appears to be part of the metal itself is readily obtained on bulk loaded parts, such as is indicated for threaded bolts in Fig. 3. A quench in soluble oil is a safe method of cooling from the process temperature, since the surface finish is retained and the oil film gives added protection against rusting. The obvious advantage over richer atmospheres is found in the elimination of low-temperature explosion hazards.



	CO_2	H_2O	CO	H_2	N_2	CH_4
Line 1	11.5	2.00(a)	—	—	86.5	—
Line 2	4.0	2.0(b)	12.0	20.0	62.0	—
Line 3	0.05	0.10(c)	20.0	41.0	38.5	0.15

Fig. 7 — Heat Evolved (or Absorbed) by Atmosphere Converter as It Varies With Air in an Air-Methane Mixture, and Representative Atmosphere Compositions for Three Conditions. Reactants at 60° F., products at 2000° F.

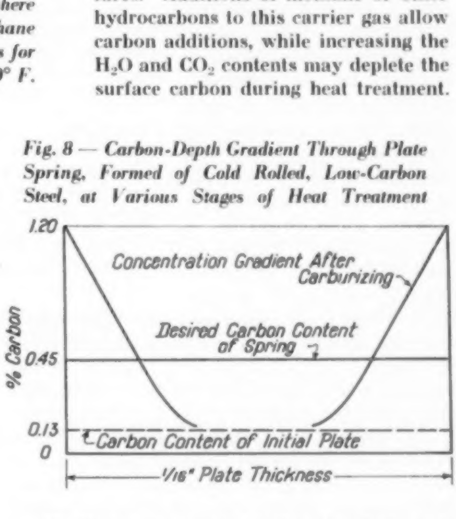
(a) Moisture reduced to this value (60° F. dew point) by cooling
(b) Dew point, 60° F.
(c) Dew point, 8° F.

The composition shown on Line 2 of Fig. 7, representing the richest mixture obtainable with the exothermic converter, has a definite field in heating operations where prevention of scale (or reduction of oxides) is of primary importance. Such an atmosphere may be produced very cheaply and with little attention. However, the composition is decarburizing* to all but very low-carbon steels, particularly at the higher operating temperatures, and its use is limited to parts where the surface concentration of carbon is of no consequence.

Development of the endothermic generator — wherein heat, aided by suitable catalysts and precise flow control, produces carrier gas of approximately the composition of Line 3 of Fig. 7 — is one of the outstanding accomplishments in aiding atmosphere control in commercial processes. While the composition shown is not a panacea for all atmosphere troubles, the operating principles for the converter are quite elementary and large quantities of this carrier gas may be continuously produced with moderate care and attention and at a relatively low cost. Many desirable processes are vitally concerned with the carbon potential, and we may well consider at some length the correlation between this gaseous mixture and the commercial requirements.

The functions of the continuously flowing carrier gas in the work chamber are to purge it of spent reaction products and to prevent contamination by infiltering air. Referring to carbon, a high potential and a low capacity factor are desired in the carrier gas. These requirements are met by high CO content (20% or more) with the low H_2O and CO_2 contained in the composition shown in Line 3 of Fig. 7. Consequently it is quite inert to most steels at the usual treatment temperatures. Additions of methane or other hydrocarbons to this carrier gas allow carbon additions, while increasing the H_2O and CO_2 contents may deplete the surface carbon during heat treatment.

Fig. 8 — Carbon-Depth Gradient Through Plate Spring, Formed of Cold Rolled, Low-Carbon Steel, at Various Stages of Heat Treatment



Heating for copper brazing of steel parts above 2000° F. is best done by exposed electric resistors, and care must be taken to avoid a high methane content which may deposit carbon on the resistor. The catalytic converter may then be supplied with a slightly higher proportion of air, so that the dew point of the product ranges from 30 to 40° F. (as compared with 8° F. for the slightly carburizing composition quoted†). The effect of the higher dew point, in general, is to eliminate methane in the final mixture —

*A 0.005-in. shim stock of 0.14% carbon may be reduced to 0.02% carbon at 2050° F. in 15 min. when heated in a gas composition which approximates Line 2 of Fig. 7.

†A 0.005-in. shim stock of 0.14% C had a carbon concentration of 0.22% after 1½ hr. at 2030° F. with this approximate composition.

although the converter conditioning, the activity of the catalyst, and the rate of gas flow are factors which must be correlated for safe operation. When making the composition of Line 3 with 8° F. dew point, as is customary for carburizing operations, sooting of the catalyst must be checked after a reasonable period of operation. Addition of steam to remove carbon, an endothermic reaction, is a promising method of returning the catalyst to its optimum condition and in a controllable manner.

Carburizing — This catalytic gas with methane additions continues to be the most practical atmosphere for ordinary carburizing practices. However, for special cycles — often very desirable from a manufacturing viewpoint — a carrier gas weaker with respect to carbon capacity may be valuable. Such a gas, made from products of combustion, with water vapor removed and then "re-formed" by passing it through hot charcoal, is very low in hydrogen and is free of methane. It has been used in the manufacture of corrugated clutch springs, formed cold from low-carbon plate, and carburized throughout sufficiently for surface hardness of C-55 (oil quenched in die). Details of this interesting practice and its economic advantages have been given in *Metal Progress* for June 1948. For the present it is sufficient to reproduce Fig. 8, which shows the carbon gradient, surface to center, of this spring after carburizing in carrier gas plus methane. The next step in the cycle, usually at a higher temperature, is the leveling off of the carbon-depth gradients on both top and bottom of the spring. This is accomplished without addition or removal of carbon, to produce a substantially homogeneous concentration of 0.45% carbon throughout the section. Here a charcoal gas (re-formed products of complete combustion) is often the necessary carrier, particularly if the final desired concentration is 0.60% C or lower. This mixture of CO and N_2 may be readily made commercially, but it does require labor for charcoal handling and so it often gets less consideration than it deserves. Since the gas may readily be strengthened by hydrocarbon additions, or weakened by increasing the carbon dioxide content, it is undoubtedly the most adaptable general-purpose carrier gas commercially available at the present writing.

Floyd E. Harris

HE GRADUATED from the University of Michigan in the Class of 1914 as a Bachelor of Science in Mechanical Engineering and, being a native of Flint, Mich., naturally got a job at the Buick plant. Shortly thereafter he moved across the state to Muskegon and took charge of heat treating operations at Continental Motors until Uncle Sam made him a Lieutenant in Army Ordnance. Since 1919 he has been with Bob Schenck's metallurgical group at Buick Motor Division of General Motors Corp. His ability to apply the fundamental physical and chemical principles in the design of modern furnaces for heat treatment in mass production is clearly shown in his numerous papers in *Metal Progress*.

Major Advances

There can be little doubt but that the major advances in furnaces and methods of heat treatments during recent years are found in atmosphere applications. Atmospheres have great advantages, but care is necessary to keep them under control. Slight changes in composition often have a comparatively large influence on the rate of addition or removal of carbon; this characteristic obviously affords the metallurgist many opportunities to improve manufacturing costs and quality standards in metal processing. This very activity, however, demands more careful choices of operational procedure, as well as a much closer evaluation of the limiting factors.

Heat application without atmosphere contamination, in many processes, is solved by the radiant tube, and the development of suitable high-temperature recirculating fans is also responsible for commercializing many desirable processes.

Establishment, by experimental data, of a rationale for commercial procedure whereby the balance between supply in the gas phase and diffusion in the solid phase may be properly controlled, is in great part responsible for the above developments. Future progress will probably be made only as these factors are better understood. While carbon control continues to hold the major interest in steel processing, much has been done with nitrogen as well. In many processes with steel and other metals, we may undoubtedly expect continual commercial developments, based on the control of surface reactions.

By A. M. Bounds and H. W. Cooper
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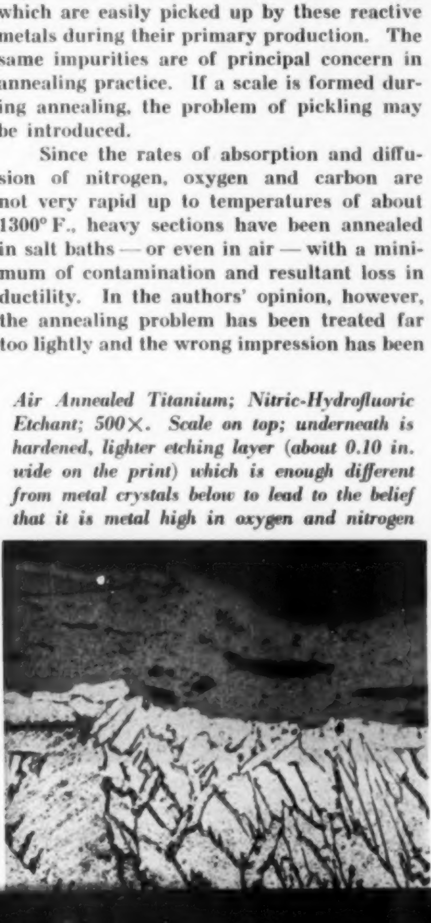
Superior Tube Co., Norristown, Pa.

Annealing of Ti and Zr

In our previous article on fabrication of titanium and zirconium (*Metal Progress* for August), emphasis was placed on the great importance of nitrogen, oxygen and carbon, which are easily picked up by these reactive metals during their primary production. The same impurities are of principal concern in annealing practice. If a scale is formed during annealing, the problem of pickling may be introduced.

Since the rates of absorption and diffusion of nitrogen, oxygen and carbon are not very rapid up to temperatures of about 1300° F., heavy sections have been annealed in salt baths — or even in air — with a minimum of contamination and resultant loss in ductility. In the authors' opinion, however, the annealing problem has been treated far too lightly and the wrong impression has been given that titanium and zirconium may be annealed by methods similar to those used on the common metals. Nothing could be further from the truth when light sections such as strip, tubing and wire are considered.

Air Annealed Titanium; Nitric-Hydrofluoric Etchant; 500×. Scale on top; underneath is hardened, lighter etching layer (about 0.10 in. wide on the print) which is enough different from metal crystals below to lead to the belief that it is metal high in oxygen and nitrogen



Up to approximately 1300° F. these metals absorb hydrogen in copious quantities. Although hydrogen has not been shown to be as embrittling in its action as the other gases, there is still a question whether it is safe to permit these metals to become loaded with hydrogen. Until proved safe, hydrogen atmospheres should probably be ruled out. Dissociated ammonia is, of course, much worse because of the hardening and embrittling effect of nitrogen, which is absorbed rapidly at higher temperatures. Fuel gas atmospheres contaminate the reactive metals with carbon, nitrogen, oxygen and hydrogen, as hot titanium and zirconium will rapidly extract these elements from gaseous compounds. Open annealing causes the formation of a nitride-oxide layer that is extremely hard and acid resistant. We know of one instance where more than 40 abrasive belts were worn out in removing such a scale from less than 100 ft. of strip.

For light sections, then, we must consider inert gas atmospheres or vacuum annealing. While purified argon produces a satisfactory anneal, it is extremely difficult to prevent slight infiltrations of air when argon is used in conventional controlled atmosphere furnaces. This is particularly true where long, thin objects must be annealed through muffles which necessarily are partially open to the air at the ends. If fully sealed retorts are used, one may as well evacuate the retort as to fill it with expensive inert atmospheres which must be thoroughly purified. Therefore, we recommend vacuum annealing for light sections of titanium and zirconium.

When an attempt was made to pickle samples of titanium tubing that had been annealed in air, the metal was attacked rapidly at the few spots where an opening existed in the scale, and the scale was affected scarcely at all. Similar samples annealed in argon could be pickled bright if not too heavily discolored, but it has not always been possible to do a good pickling job where a bluish discoloration has developed. A vacuum annealed sample is clean, bright, and *(Continued on p. 100)*


For Product Index
see page 121

By L. G. Klinker
*Chief Engineer
Metals Refining Co.
Division of Glidden Co.
Hammond, Ind.*

Prepared Pastes for Brazing Material

FURNACE BRAZING has become so widely used in production of steel assemblies that it is unnecessary to describe it in detail. The general procedure is to assemble the close-fitting individual parts, place some brazing metal (usually copper or a silver alloy) in the immediate vicinity of each joint, and heat the assembly in a protective atmosphere to a temperature where the brazing metal melts, penetrates and seals the joints. Since furnace brazing is primarily a mass-production process, the costs of the materials and the associated operations (especially labor) are important. We find, therefore, many current methods of applying the brazing material.

Snap rings of copper wire are most common, but have some drawbacks. Many times they fall off unless lacquered or cemented in place, which is an extra operation. They must be cut to size and formed, and, of course, they must be cemented on bottom-side positions.

Copper slugs are even more difficult to position. (If weight must be controlled, it is much easier to extrude a given quantity of paste, as will be described later in this article, than to produce a slug of given weight.)

Electroplating the contacting areas requires expensive equipment and often leaves corrosive residues which attack the work and the elements.

Metalizing is also a costly proposition and the equipment is rather expensive. In addition, the slightly oxidized surface is bad on interior parts where the protective furnace atmosphere does not reach only too well.

Powder metals have also been used as such, but they have essentially the same drawbacks as slugs. Powder often becomes damp and lumpy and does not flow readily onto the parts which lend themselves to such procedures. It is also very difficult to control the quantity.

A metallic paste, properly compounded and applied with specially designed equipment, has many advantages, which this article will demonstrate. However, it may first be desirable to refute the idea that prepared pastes are too expensive. How do they compare with copper rings, for example?

Suppose the copper is applied in a ring ½ in. diameter and made from No. 26 copper wire. An average cost of fabricating such rings in your own shop will be around 30¢ per 1000. (If bought outside from a ring service organization, the cost would probably be around \$1.00 per 1000.) There are approximately 9000 such rings in a pound, or the fabricating cost in your own shop is 9 × 30¢ = \$2.70 per lb. plus the cost of the wire itself (at least 30¢ per lb.) and so the cost of the brazing copper only (before it gets on the part) is \$3.00 per lb. (\$9.00 per lb. if fabricated rings are bought). Even if copper in paste form costs as high as 75¢ per lb., and ready-prepared pastes are available at a price per pound of contained copper substantially below this, the cost of brazing copper in ring form will be three to 12 times that of brazing material in paste form.

Figure 1 shows the ease with which paste can be placed at the joint. Fast application is, in fact, such a major saving that homemade pastes of copper powder or copper oxide have been widely used. This brought some new problems into the picture:

Homemade pastes settle and, consequently, can't be applied by gun methods; there are carbon residues from the vehicles; they will dry out and flake off the part; their formulation takes a lot of time; variable results follow a change in the metal powder sources or variation in the vehicle; they are messy to handle, particularly in the summer

time; a lacquer base causes considerable waste from setting-up overnight or thickening in use.

All the above disadvantages can be eliminated by intelligent formulation of commercial chemicals, given the necessary preparatory investigation and manufacturing equipment. This — together with the development of desirable applicators — has now been achieved. Several general-purpose pastes have proven themselves, since, in addition to the economy in first cost demonstrated above, they have several more tangible advantages as compared to rings:

1. It is unnecessary to stock a number of different diameters of wire. Predetermined shots of paste give a measured source.

2. There is no need to make up mandrels on which to wind rings or tie up springmaking machines or lathes.

3. Production departments are generally optimistic about the number of parts they will want, and since customers demand immediate service, enough rings to do the maximum number are made. If orders fall short, many rings are wasted. This is not so with paste.

4. There is no wasted productive time when operators are untangling linked or split rings.

5. Paste is handy to apply automatically in conjunction with assembly operations. See Fig. 2. Another method is to merely dip one of the parts to be assembled into a constant-level bath prior to press fitting. The paste acts as a lubricant in assembly and deposits the necessary copper at the junction.

6. The difficulty of threading a tight copper ring on long projections is avoided — just dot on a few spots of paste.

Copper-Iron Mixture for Brazing

The new brazing pastes are being marketed under the trade name "Cubond". Type 155 contains 4% iron and the vehicle breaks down on heating to reducing gases, the essential elements of the furnace atmosphere for brazing, so no contamination comes from the vehicle. A wetting agent is present to facilitate application to oily parts. No fluxes or other chemicals are part of the formulation.

As some individuals doing furnace brazing know, introduction of iron into the copper paste decreases the fluidity of the brazing material, thus achieving the following properties: *(a)* stronger brazed joints than with straight copper since better "filleting" eliminates "notch effect"; *(b)* savings in copper.

Economy of copper is apparently tied in with the thickening-strengthening effect of the iron. Reports indicate that on dip, brush, and spray jobs, such as are common in the refrigeration and automotive industries, only two thirds of the usual copper brazing material produced equal joint properties. Excessive running from the joint is avoided — this apparently is the main reason. A paste with 4% iron is a general-purpose material, although one with 12% iron is available.

When considering the uses where the thickening effect is beneficial, several examples can be cited:

1. Screen brazing with copper sometimes "blinds" screen openings (too much fluid copper) unless the units have been specially processed.

Fig. 1 — Assembling a Fan Ring Containing 18 Joints (Courtesy Burgess-Norton Mfg. Co.). This was formerly a welded assembly; brazing with the use of copper rings could not compete. Operator is applying paste with an extrusion gun — one spot at each joint is sufficient

2. It may salvage stampings or screw machine parts where joints are too wide to be filled by ordinary copper; the more viscous Cu-Fe alloy bridges the wider gaps with a pressure-tight joint. Many salvage jobs using the more expensive silver solder have been eliminated in this manner.

3. It eliminates drops of excess copper which run to lower surfaces of precision parts. Otherwise they must be ground off.

4. It aids in confining the copper to a given area, thus preventing indiscriminate running on such parts as those which must be carburized in later operations.

Copper Pastes

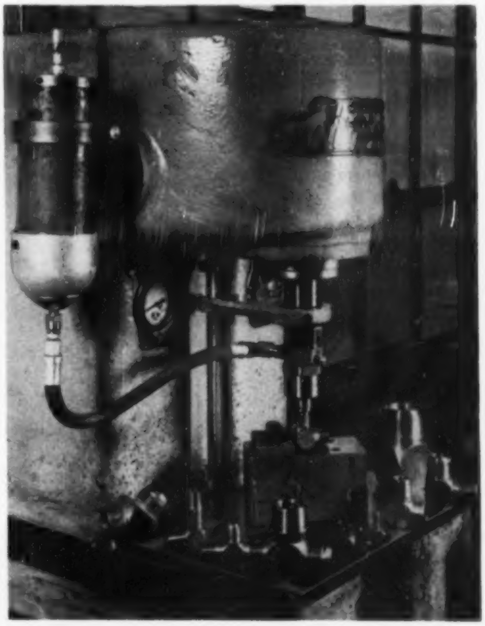
Two highly successful general-purpose pastes are labeled Cubond Types 151 and 153. The difference is in the vehicle: Type 151 thins with heat and contains a wetting agent and an anti-spattering agent. The vehicle reverts entirely to reducing gases and the amount of carbon residues is nil. It is substantially nonsettling and will not dry on exposure, nor flake off. It varies in viscosity with temperature so when the temperature rises as the part goes into the furnace, paste placed in one spot flows around the entire joint. Type 151 also contains fluxes of the borax - boric acid type.

Type 153 is a suspension, the base of which does not thin with heat. It contains a wetting agent. It has no fluxes. This carrier or vehicle is particularly suited to furnace brazing since, on heating, it decomposes substantially to hydrogen and carbon monoxide — the basic gases making up the usual reducing atmospheres. It may be thinned to paint consistency for brush applications with water, ethylene glycol, or glycerin. (Glycerin, being hygroscopic, tends even further to prevent drying.) As delivered or as thinned it does not change appreciably in viscosity with normal temperature changes.

Generally speaking, low-carbon steels of the 1010 or 1020 grade or B1112 screw machine stock are the ones most often brazed. Because of the scrap situation in the steel industry, the "residuals" are building up in plain carbon steels so they often approach a low alloy. Each alloying element tends to affect the fluidity of the copper which brazes it. A flux takes care of a variety of residuals. Likewise, low-alloy steels containing fractional percentages of chromium, nickel, molybdenum or copper are brazed. "Wettability" is increased by the flux and stronger joints result.

Fluxes in the brazing material take care of particles of oil and dirt remaining after a less-than-perfect cleaning. Lastly, tests indicate that the presence of flux increases the strength of joints materially. This was the final reason for its inclusion of the brazing compound. We assume this to be due to the extra-fluid, uninterrupted alloy between the copper and the absolutely clean steel surface on which it spreads.

Fig. 2 — Completely Automatic Application of Copper Paste During Assembly of Pipe Joints (Courtesy L. & L. Mfg. Co.). Cut-away shows blob of paste entering as side outlet is being pressed into place



Applicator units have been developed which will, at the user's discretion, apply the paste as an extrusion in the form of rounds or ribbons in definite quantities depending upon trigger setting. The guns are for hand or pneumatic use as required. Consequently, a well-thought-out scheme for economizing in labor and material is now available to the fabricating industries. Copper and copper-iron brazing pastes offer a source of inexpensive brazing compound that can be applied with the maximum speed and minimum waste, and hence will inevitably increase the applications of this method of joining in mass production.

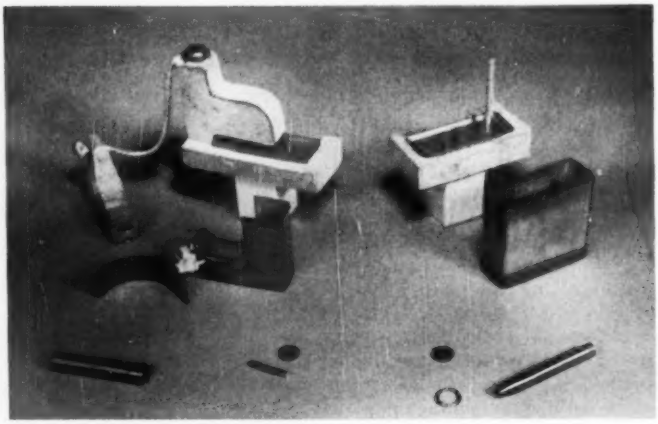
Soft Soldering in Production

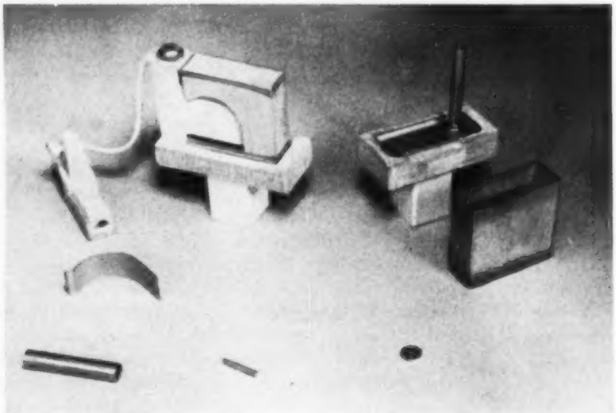
By Charles H. Yetman
Development Engineer
American Emblem Co., Utica, N. Y.

Being an entry into the contest "Economy in Production With Tocco Induction Heating"

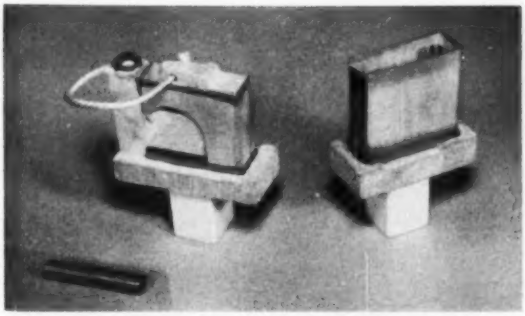
PROBLEM — To reduce prohibitive costs and speed up slow production occasioned by soft soldering, with hand torch, inner and outer case assemblies of the "Ruliter" cigarette lighter. Material is 0.022-in. brass. Length of seams in inner case: 6 in.; in outer case 4⅝ in. All seams fluid-tight. Finished cases assemble with push fit.

TRANSITE fixtures were prepared for inner case (left) and outer case (right). First assembly operation is to flux brass stampings for base of either case and place them in fixture as shown. Other necessary parts and prefabricated solder bits are in the respective foregrounds.

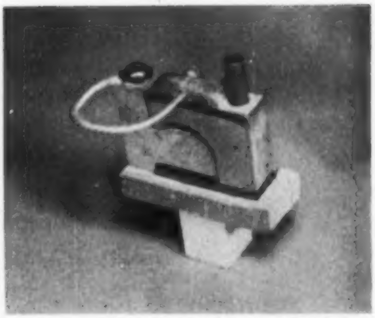




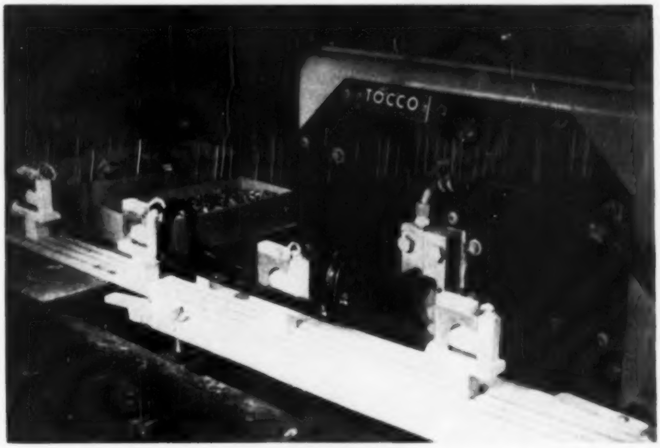
OPERATION TWO — For inner case assembly, flux shell and place it over transite rib, properly positioned inside flange on base . . . . . For outer case assembly, drop flint tube over fixture's vertical copper pin, thrust through hole in base, and drop solder ring over the tube. Tubes must be perpendicular to bases and positioned to ±0.002 in.



OPERATION THREE — Slip the curved plate, solder disk and aligning block into shell of the inner case (left) ..... Shell of outer case is fluxed, positioned on base, and solder disk dropped into shell.



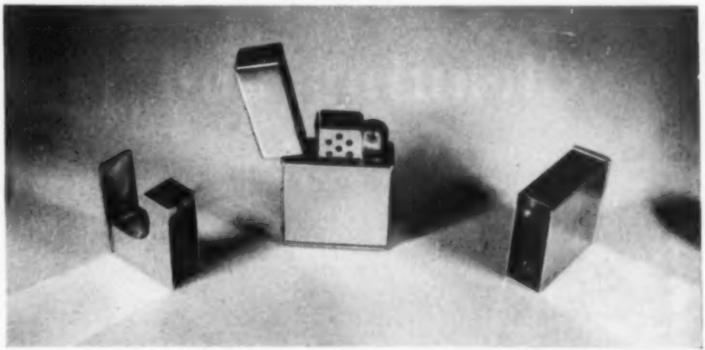
OPERATION FOUR — For inner case: Drop retainer tube through hole in aligning block ..... (Outer case is completely assembled.)

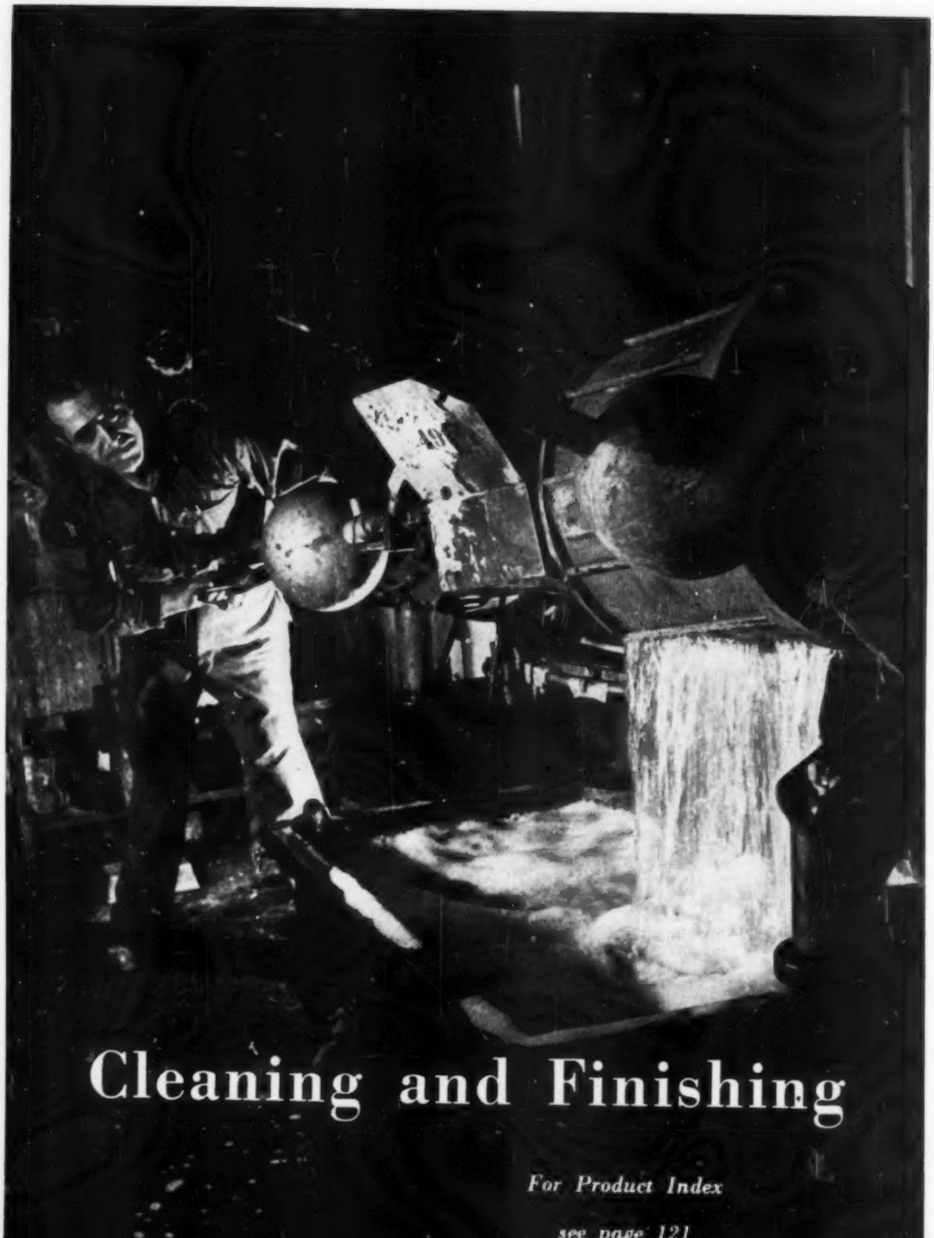


Conveyer belt carries assemblies through induction heating coils made of ¼ x ½-in. copper tubing. Equipment: Tocco 7½-kw. motor-generator, 9600-cycle; two work stations, 20-sec. heating cycle.

RESULTS

Production rate doubled.
Leakers eliminated.
Repairs of misaligned tubes reduced 98%.
No excess solder outside cases.
Buffing time reduced 20%.
Solder cost reduced 50%.
Conveyer operation and mechanical unloading reduces handling costs.
No scrap cases.





Cleaning and Finishing

For Product Index

see page 121

By Adolph Bregman
Consulting Engineer
Consulting Editor for Metal Progress
New York City

Advances in Production Methods in Metal Finishing*

METAL FINISHING has made long strides in the past five years — perhaps has advanced further than in any similar period in its past. Numerous instances of advanced equipment were on display at the ⚙'s National Metal Congress and Exposition in Chicago, late in October. Technically and scientifically, it is a hale and hearty industry, growing in size and scope. To summarize briefly its progress in its various divisions, let us start with

Metal Cleaning — A newcomer in this department is the "di-phase cleaner" and the "three-step compound". In the first mentioned, a mixture of an aqueous alkaline solution and a hydrocarbon solvent is used. In the bath these materials separate into two layers and the soil is removed by the phase which preferentially wets or dissolves it. Diverse soils are removable and the operation is free from hazards. Because of the variable schedules possible, di-phase cleaning is highly adaptable to varying shop conditions. This type of cleaner has been found particularly applicable to the removal of buffing compounds and similar stubborn soils, and it has often eliminated the necessity for solvent degreasing. In the "three-step compound" (of the phosphate type) rust, then oil, is removed, and finally the surface acquires a good "tooth" for paint.

The liquid abrasive blast has come into its own, the abrasive being propelled by water instead of air. In this manner a fine finish may be produced with a wide range of abrasives. *Dry* sand, of course, involves a silicosis hazard, and dry steel shot may result in rust spots from embedded fragments. Water as a propelling medium eliminates these evils; a common method is to make a rather thick suspension of abrasive in water, and then give this the necessary velocity, as a jet, by means of compressed air. Other forceful methods of cleaning, which throw large volumes of clear solution against the work, may also be thought of in this connection. (Nonclogging paddle wheels, or rotary pumps with rubber impellers, are necessary when metal dirt or chips are likely to be mixed with the work.)

An important postwar improvement in metal cleaning is the sodium hydride descaling process for stainless steel, which has found wide application, especially in plants which are in a position to install equipment for handling the fused caustic soda and hydrogen.

Electropolishing of silver and stainless steel is also now an established procedure, especially on flatware. The combination of electropolishing and chemical polishing on aluminum is said to produce a finish equal to the anodizing process for its reflectivity. Chemical polishing has greatly improved the treatment of aluminum and its commercial alloys.

Several interesting and efficient machines were to be seen at the Chicago Metal Show; for example, a degreasing unit, complete, ready for operation immediately after service connections are made, and embodying hot solvent tank, cool solvent rinse, and final rinse in pure concentrated vapor. Work is loaded and unloaded at

*Grateful acknowledgment is made to Nathaniel Hall of G. B. Hogaboom, Jr., & Co., for use of information from his talk on "Post-War Developments in Plating" before the Metropolitan Section of The Electrochemical Society in New York City on Nov. 8, 1950.

Advances in metal finishing — particularly electroplating and chemical methods of brightening — have been so striking in American postwar history that little more than mention of the outstanding ones can be attempted in a short review. Plating of many alloys — two or even more metals deposited simultaneously — has been perfected commercially, each for a specific important application. Bright platings, even on fairly rough surface, are saving much labor in polishing. Electroforming, sputtering, vacuum evaporation are all important techniques for today and tomorrow.

the same station, and carried automatically through the tanks in rotary baskets, thus being adaptable to small objects that require tumbling for a 100% clean-up. Devices are also available which include a motor-driven basket and a cycle (automatically controlled) in a vapor chamber. Attention is given to auxiliaries which minimize drag-out, which is not only costly but may be a nuisance to adjoining departments.

Another labor-saving device is a rotary drum washer, set on such an incline and run at adjustable speeds so 1 to 3½ cu.ft. of small, loose parts can be cleaned per hr. — that is to say, about half a ton of closely packed items such as cold headed parts.

Mechanical Finishing — Tumbling is an old art but growing in extent. Costs in modern equipment are low and excellent finishes are obtainable. For example, ball burnishing will produce lusters very close to the mirror finish.

Belt polishing is also coming back into favor. More adaptable and more rugged equipment, together with contact wheels of proper face width and diameter, density and speeds, has enabled abrasive belt finishing to extend its field of applications greatly. The equipment consists essentially of abrasive belts, back stands and contact wheels. The belts may be canvas, leather, rubber or cloth; the contact wheels, serrated or contoured, resilient or hard, as required. Advantages are longer life and better work than set-up wheels; they are easily changed and more adaptable to automatic straightline installations; they require much less stockroom inventory than would polishing wheels.

Liquid abrasives are a fairly recent and successful newcomer in the finishing field. These are polishing compounds applied to the wheel in aqueous (preferably) or nonaqueous media by a spray which may be operated with a foot treadle so the operator's hands are free. Liquid abrasives are said to spread more uniformly over the wheel, give longer wheel life, and to save much workman's time as well as material used.

Another innovation in production methods consists of the automatic polishing of steel in the flat, then phosphate coating and lubricating it to protect the surface during later forming operations. Some automobile plants are turning to this method for bumpers and other parts, with large savings.

A sprayed plastic coating, applied in the mill as a last operation before bundling for shipment, has also been a successful innovation in the production of stainless steel sheet and strip, and presumably would be worth while for any material which must be interleaved with paper to prevent scratching during shipment and handling in the fabrication shop.

Electroplating

In electroplating equipment, the rectifier, being air-cooled, has sometimes suffered from the impure air in plating plants which has badly corroded the stacks. A new type of rectifier with oil-cooled stacks may remedy this condition. An innovation in low-voltage generators is the homopolar or a-cyclic generator; the manufacturer says it is superior to the multipolar generator by reason of *(a)* lower installation and operating cost; *(b)* less floor area required for mounting; *(c)* increased generator efficiency; *(d)* greater dependability; *(e)* greater flexibility — quite an imposing list. If these claims are achieved, the new equipment would be revolutionary, since the plating generator has been considered the last word in dependability.

Periodic reverse plating is one of the foremost developments of the past decade. The method is to plate with direct current for a matter of seconds, then to reverse for a much shorter period. Automatic repetition of these

cycles produces smoother, denser and brighter deposits; large irregular rack loads can also be plated without burning and with uniform deposits over the entire load.

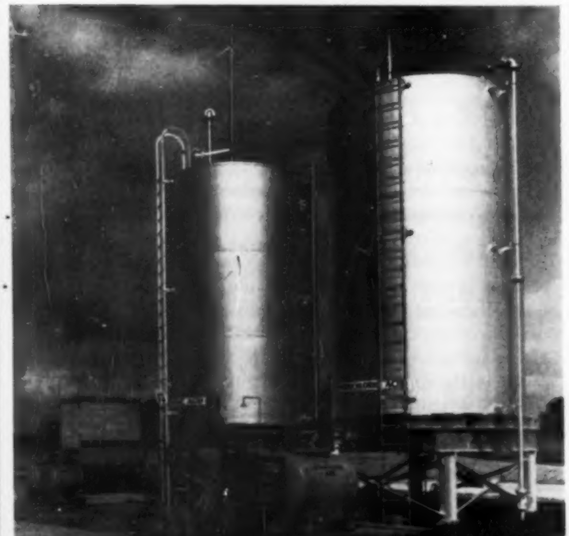
Automatic equipment for electroplating in mass production has continually been improved until a modern line-up is indeed a skillful robot. This applies to enormous machines but also to small "package" installations, as well. Since operations can be made entirely automatic from the time the loaded fixture enters the first tank until it emerges finished and dry, about the only thing left for mechanical inventors is to devise equipment for racking-up, loading and unloading — and, indeed, this is already with us.

Safe storage and handling of the considerable amounts of acid and chemical reagents assumes unusual importance in large plants. Figure 1 shows miniature tanks being handled by lift trucks in the newly constructed Indianapolis plant of Western Electric Co. The chauffeur has special protective clothing and eye protectors.

Substantial advances have been made in the graphic arts. Nickel plating of stereotypes in the nickel chloride-acetate bath; zinc plating of deep-etch offset lithographic plates; cobalt-nickel solutions for nickel on electrotypes; deposits of iron on electrotypes and in the manufacture of engraving plates; copper fluoborate bath for plating electrotypes and rotogravure cylinders — all these have been successfully used.

An interesting bath at this time is the tin-zinc solution, yielding deposits from 50 to 80% tin. Its corrosion resistance is of the order of zinc or cadmium, and it is readily solderable and weldable.

Fig. 1 — In Large Electroplating Departments, Safe Storage of Acid and Transport Into Plant Assumes Prime Importance. Photo at Shadeland (Indianapolis) plant of Western Electric Co.



Speculum plating has attracted attention in England (more than in the United States) — a coating of 55% copper and 45% tin. Attempts are now being made to work this solution with insoluble anodes, replenishing the solution with copper and tin salts, the deposit from copper and tin anodes having proven rather difficult to control. Alloy electrodes of copper, tin and zinc have been devised which operate in standard plating practice to coat electrical contactors with material which has proper corrosion resistance and conductivity. It is a substitute for gold — even an improvement, for it is much more abrasion-resistant.

The sodium zincate bath is now generally used in electroplating of aluminum. A film of zinc is first deposited by contact on the cleaned aluminum surface, the work is removed, rinsed and then electroplated with copper or nickel. For plating on magnesium, zinc pyrophosphate is used instead of sodium zincate; however, the deposit may be porous and unsuitable for outdoor exposure.

As is well known, the exceedingly rapid formation of oxide on a cleaned aluminum surface is a drawback to many industrial fabrication processes such as welding and electroplating, even though it is the basis of the metal's superior resistance to most corrosive mediums. An interesting idea, said to circumvent this characteristic of rapid oxidation, was observed at the Chicago ● Exposition:

Aluminum parts are first wet blasted by an abrasive in suspension; the surface retains a thin coating which protects it during transfer to the plating bath. Once in this bath (of the acid type) the coating washes away, settles to the bottom of the tank, and the clean surface of the aluminum accepts the electroplate.

Nickel plating with fluoborate solutions is attracting attention.

A new chromium plating bath has been announced, using a fluosilicate solution. The advantage claimed is better throwing power, the ability to plate bright even with current interruption, and a wider bright range. This may effect an important improvement in barrel plating, since the deposit will not be adversely affected by the constant make-and-break of the current through the work in the barrel.

Problems in chromium plating may become academic in view of the critical shortage in metal — at least for civilian use — even though the thickness of bright-plate is almost infini-

tesimal. Antimony plate may serve as an acceptable substitute on some parts.

The use of brighteners has swept through the electroplating shops. Nickel plating usually employs organic brighteners, but cobalt is used in one bright nickel bath. Cyanide copper solutions use metallic brighteners; acid solutions, thio-urea. (The acid copper bath is returning to the favor of technologists by reason of its easier buffing and polishing, and the high speed of deposits in new solutions.) Brighteners used for silver are ammonium thiosulphate and selenium. Zinc brighteners are molybdate; cadmium brighteners are generally organic.

Leveling solutions are a very recent acquisition to electroplating, yielding a deposit which is heavier in recesses and lighter on the high spots of rough surfaces. The obvious advantage is the reduction of grinding and polishing necessary before plating. Such a deposit is not necessarily bright, but subsequent wheel finishing is a quicker and easier operation.

Recently, a multicolor printing process has been developed in which the dyes are applied to anodized aluminum by roller coating, silk screen, or other appropriate method, and then sealed. This process is said to apply equally well to the surface of aluminum anodized in either the chromic or sulphuric acid solution. Magnesium has also been anodized, but by the use of sodium hydrate-phenol solutions.

Electroforming has now arrived at the estate of a primary process of manufacture for molds for casting plastics and rubber, pen and pencil tips and even for such large objects as band instruments.

High vacuum evaporation of metals has spread widely, now being standard practice in plastics, glass, fabrics, paper for the manufacture of thin metal sheet, wrappings, ribbons, sequins, costume jewelry, plaques, automobile horn buttons, Christmas tree decorations, molded plastic toys, mica sheets for condensers, quartz crystals, light bulbs, and even optical mirrors.

Under the shortages of metals that are developing, some industries have been turning to iron instead of copper or nickel. For example, electroforming and the graphic arts field have found electrodeposited iron suitable in a number of instances. The preferred solutions at this time are the sulphate-chloride and the all-chloride solutions. Electrolytic iron can be used effectively in building up worn parts, thereby salvaging old or mismachined pieces. Some of the electroformed articles are printing plates, computing cams, radar and plumbing items, letter embossing dies, and record stampers.

Waste Disposal

An important aspect of plating operations is the disposal of waste to prevent the pollution of streams. Methods tried to date include the electrolytic decomposition of cyanide, chlorination to form cyanate and then nitrogen, and ion exchange (which is now also in use for the recovery of metals and chromic acid). Waste disposal plants for important electroplating and finishing departments may involve extensive and costly equipment. The outdoor system shown in Fig. 1 includes sumps for collecting spent solutions, tankage for chlorine and other decontaminating reagents, and fillers for effluent.

Hot Galvanizing

An innovation in hot galvanizing which has come into wide public notice is the Sendzimir coating process, a radical departure from conventional practice. It specifies a new type of surface preparation of the base metal, namely

Fig. 2 — Microsection Through "Zincgrip" Coating Made by Sendzimir Process. Bottom is the steel base (unetched), top is mounting substance, middle light band is zinc. Note the thin accumulation of zinc-iron alloy crystals at the interface

(a) oxidation of the surface, and *(b)* subsequent reduction of this oxidized surface. The surface can be oxidized either by furnacing or by chemical means. In the latter, an alkaline cleaner removes rolling oils and is followed by rinsing and drying to oxidize the surface.

In the reduction of the surface oxides, the reaction products are gaseous and the quality of the reducing operation is controlled by composition of the atmosphere and the temperature in the furnace — an old story to metallurgists skilled in the art of bright hardening. A certain degree of desulphurization *(Cont. after insert)*

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Physical Properties of Some Liquid Metals

Compiled by R. R. Miller, Naval Research Laboratory

From "Liquid Metals Handbook", Office of Naval Research Publication NAVEXOS P-733

Name / Symbol / Atomic No.	Atomic Weight	Melting Point °C	Melting Point °F	Latent Heat of Fusion Cal./G.	Boiling Point 1 atm. °C	Boiling Point 1 atm. °F	Latent Heat of Vaporization Cal./G.	Vapor Pressure Mm.
Aluminum Al 13	26.97	660	1220	95.4	2057	3735	2260	1.0 1284°C. 10. 1487 100 1749 400. 1947
Antimony Sb 51	121.76	630.5	1167	38.3	1440	2624	383	1.0 886 10. 1033 100 1223 400 1364
Bismuth Bi 83	209.00	271.0	520	13	1477	2691	204.3	1.0 917 10. 1067 100 1257 400 1400
Cadmium Cd 48	112.41	321	609	13.2	765	1409	286.4	1.0 394 10 484 100 611 400 711
Cesium Cs 55	132.91	28.5	83	3.766	705	1301	146.0	1.0 278 10. 387 100. 515 400 635
Gallium Ga 31	69.72	29.75	85.5	19.16	1983	3601	1014	1.0 1315 10. 1497 100. 1726 400 1895
Indium In 49	114.76	156.4	313	6.807	2087	3789	483	1.0 1249 10. 1466 100. 1756 400. 1982
Lead Pb 82	207.21	327.4	621	5.53	1717	3123	203.0	1.0 987 10 1167 100 1417 400 1611
Lithium Li 3	6.94	186	367	32.81	1317	2403	4648	1.0 745 10 890 100. 1084 400 1236
Magnesium Mg 12	24.32	651	1204	88.8	1103	2017	1337	1.0 621 10. 702 100. 909 400. 1034
Mercury Hg 80	200.61	-38.87	-37.97	2.8	357	675	69.7	1.0 126.2 10. 184.0 100 261.7 400 323.0
Potassium K 19	39.096	63.7	147	14.6	760	1400	496	1.0 342 10. 443 100 581 400. 696
Rubidium Rb 37	85.48	39.00	102	6.1	688	1270	212	1.0 294 10. 387 100. 519 400. 628
Sodium Na 11	22.997	97.90	208	27.2	883	1621	1005	1.0 440 10. 548 100 696 400 815
Thallium Tl 81	204.39	303	577	5.04	1457	2655	189.9	1.0 825 10. 983 100. 1196 400. 1364
Tin Sn 50	118.70	231.9	449	14.5	2270	4118	573	1.0 1492 10. 1703 100. 1968 400 2169
Zinc Zn 30	65.38	419.5	787	24.4	906	1663	419.5	1.0 487 10. 593 100. 736 400. 844
Sodium-Potassium Alloy 56% Na 44% K (Weight %)	28.1	19	66.2		825	1518		1.0 382 10. 490 100. 638 400. 760
Sodium-Potassium Alloy (Near Eutectic) 22% Na 78% K (Weight %)	33.9	-11	12		784	1443		1.0 355 10. 458 100. 603 400. 721
Lead-Bismuth Alloy Eutectic 44.5% Pb 55.5% Bi (Weight %)	208	125	257		1670	3038		

Name	Density G./Cu.Cm.	Specific Heat Cal./G./°C	Viscosity Poise x 100	Thermal Conductivity	Electrical Resistance Microhms	Surface Tension Dynes/Sq.Cm.	Volume Change on Fusion % Solid Volume	Neutron Absorption Cross Section 2200 m./Sec.	Scattering Cross Section for Thermal Neutrons
Aluminum	2.374 at 660°C. 2.363 700 2.307 900 2.253 1100	0.260 at 660°C. to 1000		0.22 at 700°C. 0.21 800 0.205 900	19.6 at 657°C. 21.3 735 22.4 807 23.2 870	520 at 750°C.	6.6	0.21	1.35±
Antimony	6.49 640 6.45 700 6.38 800 6.29 970	0.0656 650 to 950	1.296 at 702°C 1.113 801 0.994 900 0.905 1002	0.052 630 to 0.05 730	117.00 627 117.65 700 120.31 800 131.00 900	383 635 384 675 383 725 380 800	1.4	4.5	4.3
Bismuth	10.03 300 9.66 600 9.40 802 9.20 962	0.0340 271 0.0354 400 0.0376 600 0.0419 1000	1.662 304 1.280 451 0.996 600	0.041 300 0.037 400 0.037 500 0.037 700	128.9 300 134.2 400 145.25 600 153.53 750	376 300 373 350 370 400 363 500	-3.32	0.015	9
Cadmium	8.01 330 7.99 350 7.93 400 7.72 600	321 0.0632 to 700	1.44 349 1.27 466 1.18 506 1.10 603	0.106 355 0.105 358 0.105 380 0.119 435	33.7 325 33.7 400 34.12 500 35.78 700	564 330 608 370 598 420 600 500	4.74	2900	6.5
Cesium		0.060 28.5	0.609 28.5	0.05 to mp 0.065	36.6 30 37.0 37		2.6	26	4+5=50
Gallium	6.0930 32.38 5.905 301 5.720 600 5.445 1100	12.5 0.082 to 200	1.894 52.9 1.029 301 0.8113 500 0.6524 806	0.07 to mp 0.09	25.9 29.75 27.2 30.3 28.4 46.1	735 30 to 40	-3.1	2.2	~4
Indium	7.026 164 6.974 228 6.939 271 6.916 300	0.0652 156.4		0.09 to mp 0.12	29.10 154.0 30.11 181.5 31.87 222.0 34.84 280.2		2.5	194±	2
Lead	10.686 327.4 10.536 450 10.302 650 10.078 850	0.039 327 0.037 400 0.037 500	2.116 441 1.700 551 1.349 703 1.185 844	0.039 330 0.038 400 0.037 500 0.036 700	94.6 327 98.0 400 107.2 600 116.4 800	442 350 438 400 438 450 431 500	3.6	0.2[a]	11
Lithium	0.505 300 0.495 400 0.484 500 0.465 700	1.224 180 to 427 1.045 to 1227		0.085 to mp 0.11	45.25 230		1.5	65±	1.5
Magnesium	1.572 651 1.55 678 1.536 700 1.47 750	0.317 651 0.321 727 0.332 927 0.342 1120				563 681 502 894	4.2	0.3	3.5
Mercury	13.645 -20 13.546 20 13.352 100 12.881 300	0.03334 0 0.03279 100 0.03245 200 0.03256 450	1.85 -20 1.55 20 1.21 100 1.01 200	0.0218 -37.2 0.0248 0 0.0349 99 0.0385 149	98.4 50 103.2 100 114.2 200 135.5 350	465 20 454 112 436 200 394 354	3.6	430	5 to 15
Potassium	0.819 100 0.783 250 0.747 400 0.676 700	0.195 100 0.1885 200 0.1845 300 0.1825 500	0.515 69.6 0.258 250 0.191 400 0.136 700	0.15 to mp 0.20	13.16 64 18.70 150 25.00 250 31.4 350	119-85 mp to 250	2.41	2.5	1.5
Rubidium	1.475 39.0	39.0 0.0913 to 126		0.085 to mp 0.11	23.15 50 25.32 75 27.47 100		2.5	0.56	12
Sodium	0.928 100 0.891 250 0.854 400 0.780 700	0.3305 100.0 0.3199 200 0.3055 400 0.3002 600	0.684 103.7 0.381 250 0.269 400 0.182 700	0.206 100 0.193 200 0.175 350	9.65 100 13.18 200 14.90 250 18.44 350	206.4 100 199.5 250	2.5	0.45±	4
Thallium	11.289 306.5 11.254 326.7 11.250 330.0 11.254 333.5	303 0.0367 to 500			74.0 303	401 327	3.2	3	10
Tin	6.834 409 6.761 523 6.729 574 6.640 704	0.0580 250 0.0758 1100	1.95 235 1.86 250 1.73 280 1.60 330	0.08 240 0.081 292 0.079 417 0.078 498	47.6 231.9 51.4 400 56.8 600 68.6 1000	526 300 522 350 518 400 510 500	2.6	0.55	4.3
Zinc	6.92 419.5 6.81 600 6.57 800	0.1199 419.5 0.1173 600 0.1076 800 0.1012 1000	2.23 600	0.138 500 0.136 600 0.135 700	35.3 419.5 35.4 500 35.0 600 35.70 800	785 510 778 550 768 600 761 640	6.9	0.9	3.6±
Sodium-Potassium Alloy 56% Na 44% K (Weight %)	0.886 100 0.850 250 0.814 400 0.742 700	0.274 100 0.267 200 0.262 300 0.260 350	0.546 103.7 0.316 250 0.230 400 0.161 700	0.0617 100 0.0633 200 0.0648 300 0.0675 500	33.0 50 35.5 100 38.0 150 41.0 200	110-100 mp to 250	2.5	1.1±	3.2
Sodium-Potassium Alloy (Near Eutectic) 22% Na 78% K (Weight %)	0.847 100 0.811 250 0.775 400 0.703 700	0.231 100 0.226 200 0.224 300 0.223 350	0.468 103.7 0.279 250 0.205 400 0.146 700	0.0583 100 0.0636 400	37.5 50 41.0 100 44.0 150 47.0 200	120-110 mp to 250	2.5	1.7	2.3
Lead-Bismuth Alloy Eutectic 44.5% Pb 55.5% Bi (Weight %)	10.30 200 10.20 300 10.10 400 10.02 500	144 0.035 to 358	1.7 332 1.38 450 1.29 500 1.17 600	0.022 160 0.023 200 0.024 240 0.027 320	113 200 118 300 123 400 128 500	367 800 356 1000	0.0	0.17	9.9

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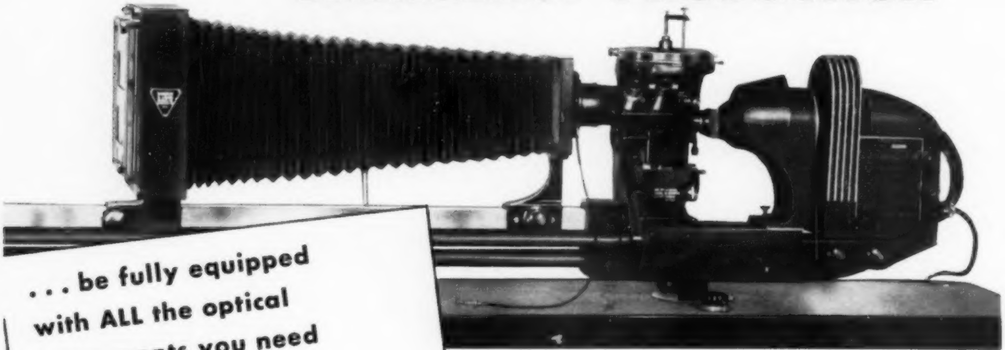

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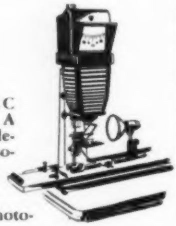

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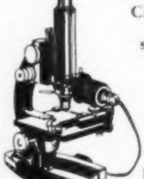

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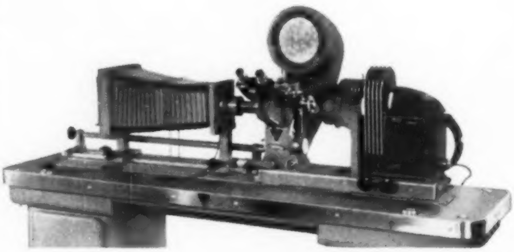

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and decarburization also occurs at the surface.

After the two steps described, the surface of the base metal is fully prepared for the molten zinc bath. Figure 2 on page 80 shows the microstructure of the coating and Fig. 3, below, the controlled atmosphere furnace for preparing the steel surface.

Nonmetallic Finishing

The electrostatic spray is now widely known for its ability to coat objects of complex shape on all sides with the least labor and losses of material. Similar electrical principles are used to remove "tears" or drip of liquid from parts.

Plating rack coatings, using "plastisol", can now be applied in heavy coats with one dip over a prime coating.

Chromate coatings have rapidly come into wide use as protectors of zinc and cadmium, ranging over a variety of colors, as preventives of corrosion under adverse atmospheric conditions. Weak dichromate solutions, used as a quench immediately after hot galvanizing, are a cheap and very effective method of preventing "white rust" on galvanized articles stored in humid surroundings.

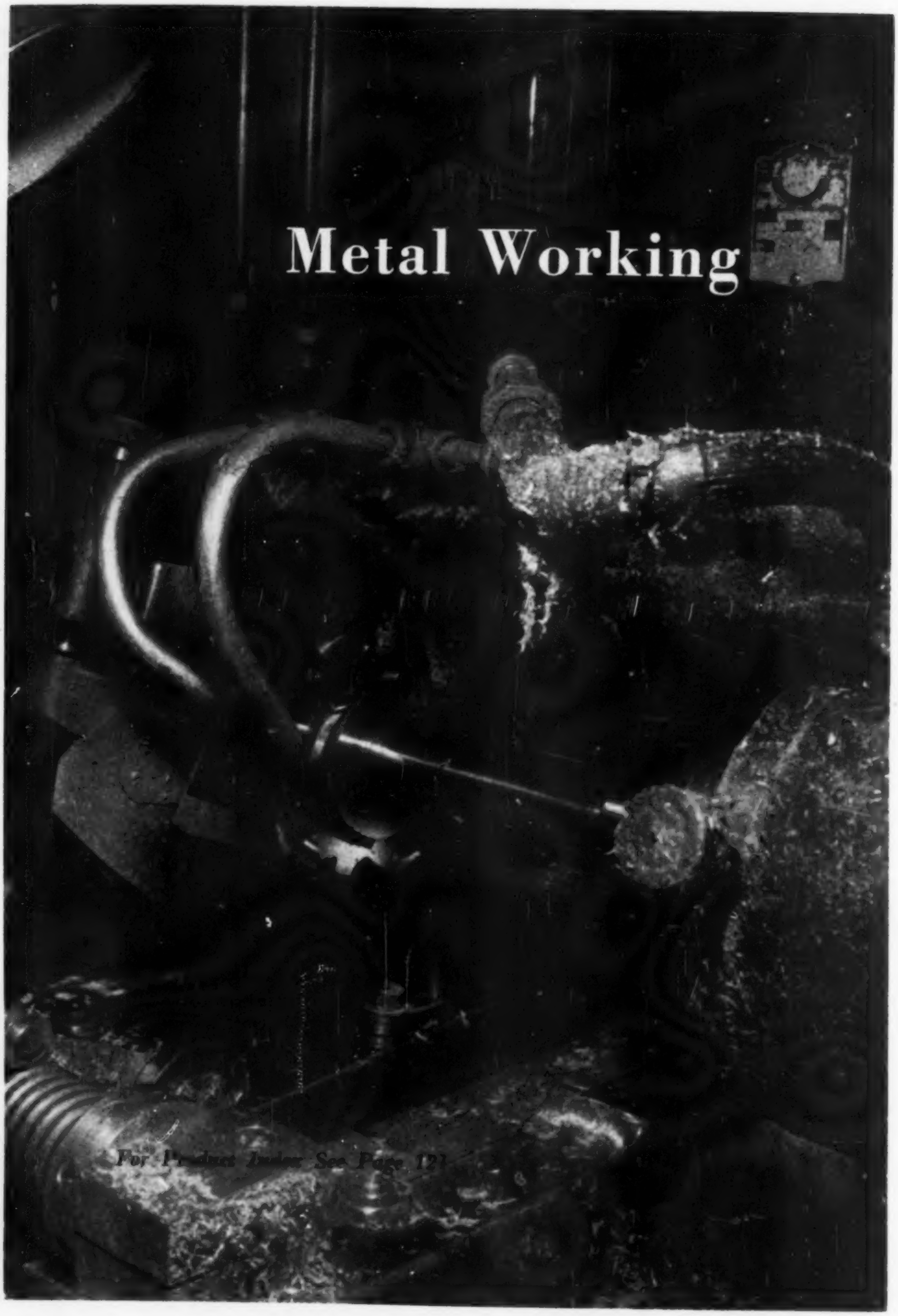
A recent innovation in nonmetallic finishing is the use of hot lacquers (at about 150° F.) to carry a higher proportion of solids in the material used, so that one coat will suffice, instead of two, yet without "sagging" of a thick coat and also (and very important) without "blushing". Organic coatings have also been applied by "flame spraying", as in the metallizing process of spraying molten metals. This is successfully used for finishing as well as for building up strip coatings on lubricated patterns or mold cavities to produce plastic products in sample lots and small quantities at low cost.

Shortages of Materials

The current shortage of materials is, of course, the most pressing commercial problem on Jan. 1, 1951. Nickel, cadmium, zinc, copper are rapidly vanishing from the non-DO market. Chemicals such as hydrochloric acid, chlorinated hydrocarbon solvents, cyanides, cadmium oxide, nickel sulphate and chloride, and others are also hard to get. Substitutes are usually unavailable as they are usually also scarce. For this condition, the present author knows of no cure except world-wide and assuredly continued peace, and for obvious reasons, he must leave the subject at this point!

Lastly, it is suggested that an outstanding contribution to advances in production methods in metal finishing resides in the work carried on by the American Electroplaters Society in its program of research projects. Space does not permit a description of all the undertakings by the A.E.S., or even a listing in full, but the progressive worker in electroplating will be amply repaid for any time spent in reading the following articles from the 1950 *Proceedings*: "Reporting and Use of Research Data", by G. M. Cole; "Why Pay for Porosity Research?" by W. H. Wesley; "Use of Radioactive Isotopes for the Determination of Current and Metal Distribution in Electrodeposition", by John Krausbein.

Fig. 3 — Continuous Furnace for Preparing Wide Strip for the Sendzimir Coating Process. Progression is from right to left. At right edge of photo is pay-off reel; then punch rolls and strip tension device; then oxidizing furnace (with open door); then reducing furnace, extending toward left beyond control panels


Metal Working
For Product Index See Page 121

By S. K. Rudorf
Supt. of Tools and Maintenance
General Machinery Plants
Allis-Chalmers Mfg. Co., Milwaukee

Tools for High Production

WHEN the Lord created Paradise and put in it those remote ancestors of ours, Adam and Eve, man's dissatisfaction with Paradise began. He then felt obliged to cut it up, to fill in the holes, level the mountains and generally improve on the work of the Creator. To do this, he had to have some tools, and undoubtedly the first of these tools were digging or cutting tools. History doesn't record just who it was that first discovered that a vine or piece of wood could be cut by mashing it between two stones, but I am sure that is the way that discovery was made. I don't suppose it took any work of genius for man to discover that if the stone had a sharp edge it would do a better job.

Those same principles are just as significant today. The sharper the edge, the greater the pressure (generally, under the edge), the more effective the tool becomes.

The next lesson was probably this one: That to cut more material you have to put more power into the cutter. In other words, if you drive a given tool harder, put more momentum behind it, it will penetrate more deeply. I am sure that discovery didn't take too long.

The cutter is no longer a stone, held in the hand, but a complex shape, and a very carefully formulated and treated material. It is arranged to displace material in the most efficient manner and it has generally seen a great deal of improvement. It is supported by a cutterhead, a tool holder, perhaps some sort of a chuck, and instead of man beating against a stone, the machine now has a bed or table to which the work is securely fastened.

However, as I said, the principles underlying the entire business are still the same. It must have a sharp edge; the edge must be harder than the material it is to cut; it must be guided with an appropriate force, either pushed or pulled. Aside from the fact that a cutting edge must be made from a material sufficiently tough that it does not break under the cut, it must be as hard as it is possible to make it. Now when hardness and toughness can be *combined*, then the greatest satisfaction is obtained. That ideal has been striven for (by what we would now call toolsteel metallurgists) since prehistoric times.

Consequently a rivalry between the product designers and the tool designers has continued through the years. The steels for modern engineering devices became tougher and harder and the cutting tools and machine tools had to keep pace. Today, many materials are being machined which a few years ago were on the border line of attainability.

Tough Babies — In the plant with which I am associated, Allis-Chalmers, it is our lot to strive continuously for materials which are able to stand up under higher and higher temperatures and stress conditions. We manufacture gas turbines and steam turbines, in addition to many other products requiring severe duty. Now, a gas turbine is a peculiar thing in that its efficiency is notably increased with even a slight increase in operating temperature. It seems to be a general characteristic of alloys usable at such high temperatures that they are "unmachinable" at room temperature, in the common sense of that term. Nevertheless, selection is dictated by the *operating* conditions, not ease in manufacture, and you must find a way to cut these materials.

One of them is called S590. It contains roughly one fifth each of nickel, chromium, cobalt, and iron, and the other fifth divided between molybdenum, tungsten and columbium. It is next to impossible to cut by ordinary means. The carbide tools don't do too well. There are times when they cut and times when they don't. Once we had to tap blind holes in S590. The manufacturer of the material wasn't of much help, so if we were going to learn how to

tap that stuff, we had to do it ourselves. Eventually, we were able to machine it satisfactorily by paying a lot of attention to insignificant detail, such as the exact choice of a coolant, the rigidity of the machine, the speed (quite slow). When all of these conditions were set up perfectly, the material became machinable! So now our designers are planning on something a little tougher, and I hope we in the shops can keep ahead of them.

This article is a condensation from the stenographic report of one of the high-production sessions at the A.S.M. convention in Chicago last October. Mr. Rudorf's talk sparked a vivacious discussion on cutting tools, machine tools, hot-spot machining, cutting fluids and machinability of metals. He outlined the 50-year development of machine tools in a constant attempt to match improvements in toolsteels and tool alloys. He believes American equipment, even honestly built machines of considerable age, has unexplored possibilities for removing metal at very high rates.

Vitallium is another material for turbine parts that is ordinarily considered to be nonmachinable. It contains about 64% cobalt, 28% chromium, 6% molybdenum and 2% nickel. Gas turbine blades of vitallium, at the root, the point of attachment to the disk, must be milled into a serrated shape with very high accuracy. Again, by trial and error, we learned that the material could be machined with carbide tools, although it is surprising that a tool for cast iron cutting did the job, where a cutter for steel did not. We found that a relatively small difference in use of coolant would represent the difference in machining it or not machining it; also a very small change in tool angles meant successful tool life or no life at all.

Now, I am not telling you all of our troubles and solutions here without a point in mind — ultimately to sell you the idea that today's tools and today's machines are not so bad, and that we have a lot to learn about their utilization.

Gem Stones for Cutting Tools

Lately certain other cutting tools have resulted from the search for increased hardness. The gem stones are viewed with considerable envy. The diamond, of course, is the hardest substance known to us. Next in line is the sapphire. While the diamond is prohibitively expensive, sapphires can be made synthetically.

A sapphire tool looks just like a carbide tool, except that the tip is a synthetic gem which has all the properties of the natural stone and is capable of taking an extremely keen edge. These artificial gems, unfortunately, are very brittle and I believe they have not been used for machining steel. They have had limited success on nonferrous materials, but where they really shine is in the high-speed machining of plastics for fine finish, such as a fountain pen barrel. For such purposes diamond tools were also used with great success.

As you know, not all the so-called "diamond boring machines" actually employ diamonds. The term applies to a whole range of machine tools with extremely rigid spindles and work-supports. Normally they use carbide tools. However, for many nonferrous metals, the diamond itself has been used as a cutting tool and it is finding increased usage.

A lathe tool with a small natural diamond set into it can be bought on today's market for about \$65. If you don't break it — and that is a big "if" — you probably never will wear it out. The chances are you will break it before long. We dream of the day when we can have this diamond hardness with the ductility of ordinary carbon steels!

Carbide Tools and High Speed Machines

The carbide tool actually is the most widely used tool in high-production machining today, doing in all likelihood about 70% of such jobs. Carbides have an interesting history. As you know, they were commercialized in America shortly after World War I; the material is synthe-

Fig. 1 — Lathe Tool With Sapphire Tip, About Half Size

tized principally from tungsten carbide powder, whose particles are excessively hard and brittle, held together (cemented) with a little ductile cobalt. The material at first was used only in the form of a very small tip, mechanically clamped or brazed to a steel shank of some sort. It took many years of development by numerous firms to perfect it into the relatively tough and inexpensive material it is today.

A few years ago, it wasn't considered satisfactory for machining steel, especially with interrupted cuts. Today, interrupted cuts are commonplace. Steel castings which as little as

Fig. 2 — 18-4-1 Cutter of Special Design for Contour-Milling Stainless Iron Turbine Blades

10 years ago were machined with high speed steel at perhaps 60 ft. per min. are now being machined at 300 ft. per min. using carbides. In cast iron, where a high speed tool would stand 70 ft. per min., 200, 300 and in extreme cases 450 ft. per min. can be done with carbide. Some grades of stainless were never satisfactorily cut with high speed steels, yet can be cut entirely satisfactorily with speeds up to 300 and 350 ft., using carbides.

Most aluminum alloys are relatively easy and fast to machine, but some of the cast alloys were difficult. Carbides solved the latter problem, and I don't believe the upper limits of machining speed on aluminum (or magnesium) have ever been reached or even approached. Handbooks mention 1000 and even 1500 surface ft. per min., which is usually beyond the possibilities of the machine tool. Some milling machines for magnesium have been made in the last five years that take off metal at an unbelievable rate, and perhaps some day the machine tool builders will come up with spindle tools having the even higher speeds we want to use.

I do not want to leave the impression that the machine tool builders have not given us outstanding machine tools in the last decade. They have. The range of spindle speeds has been greatly extended. The rigidity of present machines was unheard-of as little as five or six years ago. Applied horsepower has climbed to the point where there is practically no limit to what we can pour into a tool. And the metallurgists, on their part, have not done badly in giving us the cutting tools. I think largely we in the machine shops and production lines have failed to get the most out of the combination.

Notable Achievements in Cutting

May I speak about some of the unusual things that have been done — speaking from Allis-Chalmers' experience only because I am most familiar with it.

A typical job in our plant is the contour-milling of steam turbine blades of nitrogen-bearing chromium-iron. The stock itself is a tough material — perfectly machinable, of course — but it is not simple to remove metal at high speed. We had been using carbide tools, and we were quite satisfied that we were doing as well as everybody else. Through an entirely different investigation we came up with a slightly unconventional design of cutter tool, made of ordinary 18-4-1 high speed steel, and lo and behold, we were able to increase cutter speed 60% and feeds 450%.

That is now a production operation. Such speeds are usually considered beyond the capabilities of carbide tools. I don't mean to belittle good carbide cutting tools; perhaps if we were smart enough, we could use them to surpass even these results.

Production engineers for an Eastern concern recently hit upon an idea that has dumfounded them as well as some of the spectators. They were using one of the well-known duplicating lathes, and the tool was fed into its work by a hydraulic cylinder. They discovered quite accidentally that if air got into the hydraulic circuit (normally, everybody tries to keep air out of a

Fig. 3 — King-Size Chips From a Steel Casting

hydraulic circuit) they got some very surprising results. Most of them were bad, but occasionally they were phenomenal. So they systematically built all sorts of hydraulic controls and found by putting in 4% of air with the oil, thus establishing a "cushion", they were able to machine some materials five to ten times faster than the tool would ordinarily stand.

We at Allis-Chalmers were quite interested in that, because we had been having a great deal of difficulty in the finishing of chilled rolls for flour mills. We sent our engineers to the Eastern plant and discovered that, first, they didn't know why it worked this way, and second, they could not consistently reproduce the results. It didn't work on all materials, but the fact is undeniable that sometimes, when the right conditions are reached, the rate of stock removal is simply phenomenal. Some people, in seeking a theoretical explanation, have talked about natural frequency of materials, which, under the circumstances, doesn't seem to make too much sense to me. While I don't recommend that you go home and pump air into your hydraulic systems, heaven forbid, but, gentlemen, believe me, I have seen it work. Once in a while it does, and I wish more people would play with it!

In this room I see Sam Tour, a lifelong member of your Society, who followed another line of reasoning. I would like to think that he was buttering his toast one morning at breakfast and it occurred to him, as to many of us, that warm butter cuts easier than cold butter. He reasoned that perhaps if we heated steel (instead of dumping on pails and pails of coolant) and softened the material, maybe it would machine a little faster.

It did and it does! Perhaps Mr. Tour will tell us about the details, first hand, of the astonishing results he obtained on a lathe.

This type of thing is referred to as "hot spot" machining. As the name implies, you heat only the spot where you want to do some work. On the other hand, other people have heated the entire part prior to machining. For instance, die blocks, especially forging dies that have to be reconditioned, are sometimes quite tough; they have hard spots and are not easy to machine. It has been proposed that such die blocks be preheated to 1000 or 1500° F., quickly slapped on the machine table and milled.

Unsuspected and Inherent Qualities

Nearly all of this experimentation, so briefly reviewed, has been done with the machine tools and tool materials commercially available today. The tricks have all been in the *application*. Let us avoid the tendency to wait for somebody else to do something. A man having trouble in milling "vitallium" might throw up his hands and say, "I'll wait until there are cutting tools made to cut this stuff."

The cutting tools are here today. All we have to do is learn how to use them. High speed steel isn't completely exploited by a long shot!

For example, visitors in our steam turbine plant are usually surprised at something that is commonplace to us — chips 2¼ in. wide by ⅜ in. thick, removed with high speed steel on large machine tools such as a boring mill. The particular machine in our shop was designed in 1928 — a 40-ft. boring machine — and was installed in 1929. It has been running steadily ever since;

18-4-1 high speed steel tools for it are still being forged by the same people in the same tool room in the same way, yet we are achieving rather unusual results by controlling tool contours. The shank dimension is 2½ in. square. The tools start out as pieces of steel 18 in. long and we resharpen them until the piece is used up. This particular job is to cut the risers off a steel casting some 16 or 17 ft. high for a turbine casing. It is primarily a question of a heavy enough tool, a good enough holder, and high enough horsepower. Keep in mind that the cutting speed is very low. The boring mill is capable of a maximum of 4.5 rotations per minute, but we keep it down to 3.5 to 3.8. This boring mill is 40 ft. between columns. It has two swiveling tool holders on the cross-rail. In cutting off the risers in the large steel casting, more or less cylindrical, the two tools are arranged to approach each other, dividing the cut between them. One tool starts to cut shortly after the other one, and they progressively work inward. We have found, especially in a deep cut like this one gets to be, where the tool sticks out a long way from the holder, that its face contour is extremely important. We need a large sweeping radius on the face of the tool to bring the chip out. When this radius is too small, the chips will bind in the cut or slot. So the radius of the face of the tool is very important, but it is determined strictly on a cut-and-try basis.

Programs for Machine Tool Replacement

Generally speaking, industry has allowed its machine tools to reach a condition that shouldn't happen to a dog. Top management sometimes tends to lose intimate contact with its shops, and sometimes is more anxious to have a good-looking profit and loss statement than to invest in new machine tools.

Now, scholarly books have been written in an attempt to make a scientific analysis of machine tool replacement, supplied with charts and curves and figures. If you make the right assumptions and if you have your facts straight, you come up with an answer as to whether you should or shouldn't replace those machine tools.

That approach has found wide acceptance, perhaps because it is a scholarly approach, the debits equal the credits, and all the figures make people happy. However, in most plants we don't need higher mathematics to tell us when we ought to buy a new tool! Yet many production men will find they are much kindlier received by management when they have their whole story completely documented.

Even though industry generally has permitted some of its tools to lapse into a disgraceful condition, may I point out that the machine tool builders themselves are not guiltless. On one visit to such a plant, so help me, there was more cowhide going around on pulleys overhead than I have seen since I was a boy.

The machines that we have purchased lately at Allis-Chalmers have been bought a little too big, a little too heavy, and with a little too much horsepower for present-day standards. For instance, we have just bought a 30-ft. boring mill, very similar to the big one that made the chips I described earlier. It has a total of 300 hp. going into the table, whereas we don't really see where we can use more than 175 or 200. We asked the makers to put rigidity into it far exceeding today's requirements because we suspect that this machine, representing pretty close to a $650,000 investment, is going to be with us 20 or 25 years, and we want to be ready for future Sam Tours who will dream up ways to get stock off faster.

Generally, I believe, the trend in industry has been in that same direction. Everybody's machine is getting a little heavier, and can run at higher speeds.

I am told by machine tool salesmen that the first things prospective customers usually want to know are "What increase in production can I get with your machine? What savings can I make? Can I pay for your machine in three or four years?" That is usually all. Those items of course are important, but there are other important things you will get from a really good machine tool — better quality, much less scrap loss (which is in itself a better quality), ability to stand up to improved tool materials, ability to produce at peak loads in an emergency. Employe morale also rises with good tools!

Photo Credits for This Issue

Cover photo by Carl Bartley of United Engineering & Foundry Co.'s mill, newly installed at the Otis (Cleveland) plant of Jones & Laughlin.

Page 54 — Styrene storage tanks at U. S. Rubber Co.'s plant for manufacturing synthetic rubber.

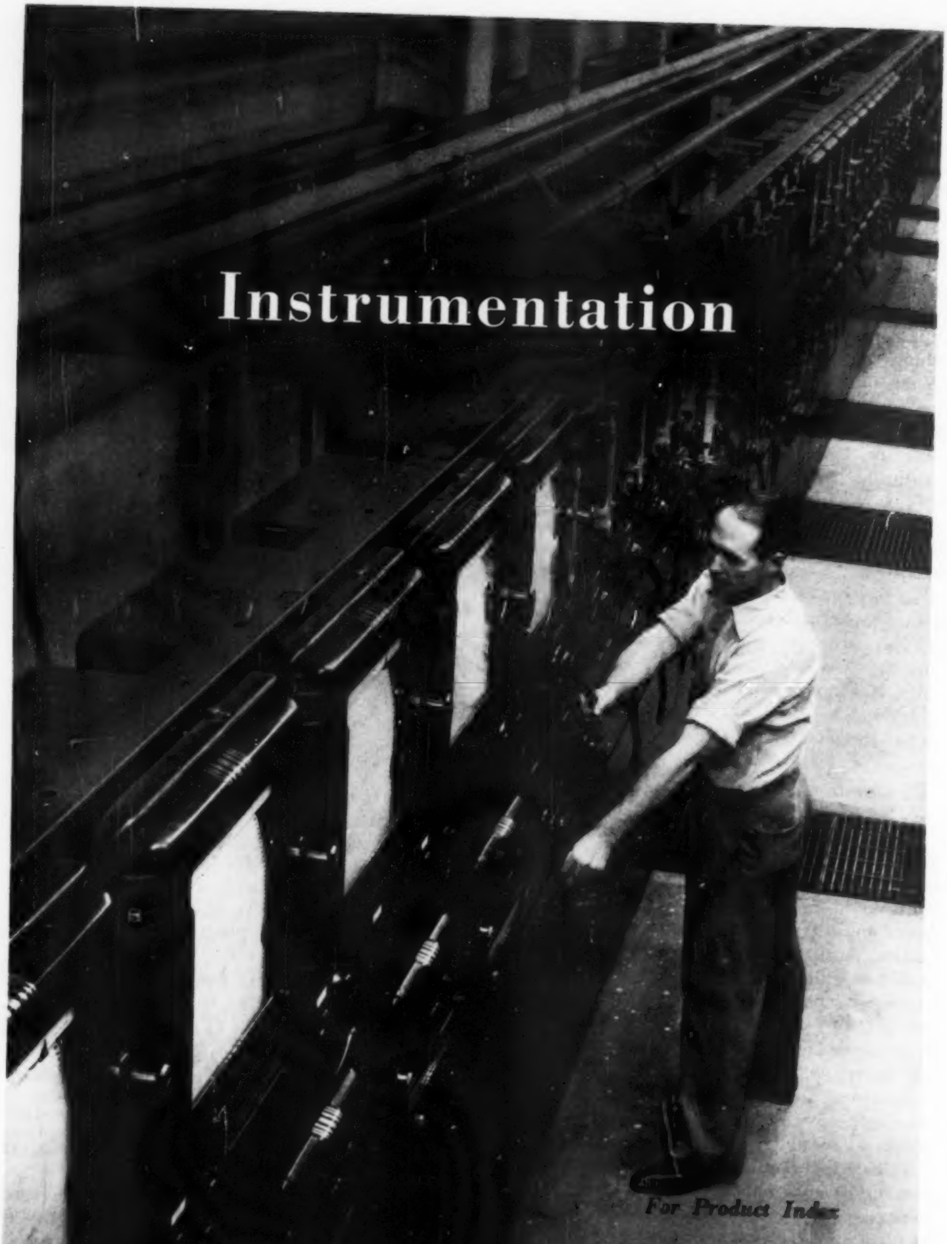
Page 62 — Load of camshafts entering Surface Combustion Corp. carburizer at Buick's Flint plant.

Page 70 — Fuselage frame for trainer in welding jig. Courtesy Linde Air Products Co.

Page 76 — Barrel for plating copper-tin-zinc alloy on electrical conductors at Westinghouse Electric Corp.

Page 80-F — Osrud miller and carbide tools for high speed milling of aluminum extrusions for aircraft members. Courtesy Lockheed Aircraft Corp.

Page 86 — Pyrometer and ammonia controls for nitriding furnaces at Wright Aeronautical Corp.


Instrumentation
For Product Index
see page 121

By R. R. Webster
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

Instrumentation for Metallurgy

Metallurgical processes are not simple to control. Few of the properties of metals are easily measurable during processing; in most instances the direct control of the process is consequently impractical. For example: A bar of steel is heated to make it plastic before it is hot rolled. The heating operation is not controlled by metal plasticity but by metal temperature or (almost always) by furnace temperature and heating time. This indirect approach is found at frequent locations from the processing of the ore to the finished product. Rather than regulate the process directly from product characteristics, it is therefore necessary to start with known raw materials and maintain a uniform processing environment so that the product will remain constant as long as the raw material does not change. This requires that all process variables be stabilized or regulated.

METALLURGICAL instrumentation has taken on a new significance within the past ten years. As late as 1940, instrumentation was spoken of as "an aid to the operator". Today, it is the essential controlling means which enables modern producing units to far outstrip manual control in rate of output and quality of product.

Such increased realization of this importance to industry is illustrated by the fact that the output of industrial instruments has increased more than ten-fold in the past ten years. This accelerated industrial acceptance has been matched by rapid improvements in the available equipment. This could well be called the "electronic decade" since a majority of the new devices have made use of this adaptable medium to increase the speed of response, the precision and the reliability.

Automatic control, an integral part of instrumentation, also has made large advances. Some of the progress has been due to developments for the armed forces during World War II, but much is the result of a continuous demand from users for more precise and reliable process control. As a result the complexity and number of types of control systems has been increased, but this situation has been countered by efforts to systemize the basic control methods so their characteristics are more readily understood. An understanding of the techniques of measurement and control is further aided by educational institutions throughout the country which now teach instrumentation at the mechanic, technical undergraduate and graduate levels. Industry has also progressed in this respect by conducting courses on the subject for plant personnel.

Examination of the metals industry will show that progress in instrumentation has not been limited to any one part of the field, but has shown itself in all the various phases of metal processing.

Melting Furnaces — The openhearth furnace consumes large quantities of fuel and most of the instruments around a modern furnace are concerned with regulating the firing to obtain high fuel efficiency and rapid production. Normal instrumentation includes air and fuel rate recorders, fuel totalizers, and air-fuel ratio control. Where two different types of fuel are used (gas and oil), the control is arranged to function with either of them. Temperature recorders for the regenerators can be arranged to reverse the furnace automatically on a set temperature differential. Some furnaces are reversed by automatic time controls; in others, by a combination of time and checker temperature.

Several instruments, in addition to those directly concerned with combustion control, are used in the openhearth. Operating temperature is only slightly lower than the melting point of the silica roof, and recording roof pyrometers are a valuable safety device. Sometimes the pyrometer is connected to an alarm; in others, to the automatic fuel control valve. The general use of roof pyrometers has appreciably increased

the rate of furnace production, since the roof can be safely operated much closer to its failing temperature. In an effort to increase the rate of heat transfer from flame to charge, some metallurgists are experimenting with highly luminous flames of increased radiation intensity, and instrumentation has been developed for determining the radiation from such flames.

Because the openhearth has several doors and ports, air infiltration has caused appreciable heat losses. Sensitive pressure controllers on the stack dampers allow the furnace pressure to be balanced against atmospheric pressure and so the leakage of cold air into the furnace is held to a minimum.

An outstanding development in the control of the refining operation has been the pyrometers for measuring the temperature of the molten metal bath. Previously, indirect methods were used and were only partially effective, but the new pyrometers will measure liquid steel temperatures to a reported accuracy of ±10° F. Most openhearth shops now have them installed either for experimental or for routine operation. Recent publications indicate a definite improvement in furnace operation and quality of product.

Two entirely different systems of measurement are being used in the bath pyrometers. One, an importation of English technique, is the Schofield-Grace immersion thermocouple. This has a platinum element; the tip is encased in a thin, expendable sheath of quartz, and the remaining part of the couple is suitably protected by refractory. The thermocouple is connected to a high speed recorder and it is claimed that accurate measurements can be made after 10 to 15 sec.

The other system uses a photocell or a radiation thermopile mounted in a heavy-walled steel tube. A source of filtered, compressed air is connected to the outer end of the tube and the other end is inserted through the wicket hole of the furnace door and down through the slag. The slow stream of compressed air is just enough to keep the inner end of the tube open, and energy radiated from the liquid metal actuates the detector at the cold end. The latter equipment is connected to a high speed recorder and readings are obtained in about 5 sec. The steel tube is somewhat protected from the liquid steel by a layer of slag that adheres to it as it passes through the slag cover into the steel bath. Figure 1 shows a pyrometer of this type being removed from the furnace.

Fig. 1 — "Blowing Tube" Bath Pyrometer Being Withdrawn From Openhearth Furnace. Courtesy H. T. Clark and Iron & Steel Engineer

Both of the above methods appear to be giving satisfactory results and, while one method may sometimes show some advantage over the other due to peculiarities of the shop or process, it is expected that industry's final choice will be based on the over-all cost of operating it.

Bessemer Process — Until 1940 the operation of the bessemer converter was entirely dependent on the skill of the operator. He judged the operating temperature and progress of the blow by watching the sparks and flame issuing from the converter's mouth. These changes are rather obscure, and therefore trainees required a long period of apprenticeship under an experienced operator before assuming responsibility.

The situation was improved when the photoelectric flame recorder became available. This instrument determines the end-point of the blow with precision and also serves as a guide toward uniform operating temperature. Since the information is recorded on a chart, the performance of each operator can be conveniently examined, checked and rechecked, with the result that the bessemer operation has become predictable and the uniformity of its product has been improved.

During the recent revival of interest in the bessemer process, the spectroscope, originally used to a slight extent in the early days of the process, was investigated in several shops and subsequently has been incorporated into the control. Its primary use is for end-point determination.

To obtain full advantage from bessemer instrumentation it is necessary to maintain uniform blowing conditions, and to this end automatic blast pressure regulators or air flow controls have been installed on the air mains leading to each converter.

Soaking Pits and Heating Furnaces

The control problems of the modern soaking pit and the reheating furnace are in many ways similar to those of the openhearth. Fuel efficiency must be maintained at an equally high level and therefore the instrumentation for fuel handling is comparable in the two. In most direct-fired equipment the atmosphere is made as nearly neutral as possible to reduce scaling of the hot metal, and flame characteristics are regulated to produce an even distribution of heat rather than an intense, concentrated flame. To maintain soft, spreading flames in soaking pits, a low calorific fuel such as blast furnace gas often is combined with coke-oven gas. Sometimes the instrumentation is designed to maintain a constant rate of heat input with such fuel mixtures.

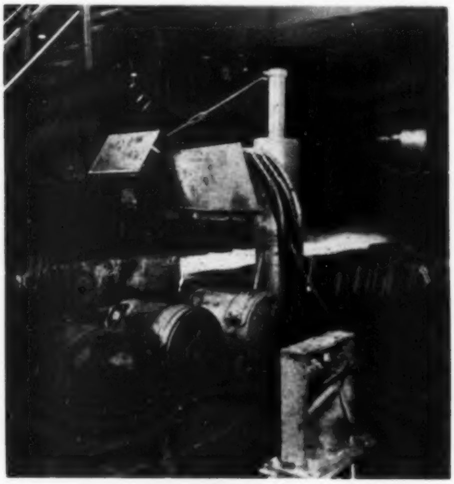


Fig. 2 — General Electric X-Ray Thickness Gage on Hot Strip Mill. The source is below the table, the receiver is swung from the side post, above the hot strip

For high temperature measurement (2000° F. and over) the noble metal thermocouple with its fragile refractory protection tubes has largely given over to the radiation-thermopile type of primary element. In heating furnace installations the thermopile is sighted on a closed-end, thin-walled refractory tube which projects slightly into the furnace. With flames of low luminosity, the instrument is often sighted directly on the refractory wall or on the charge. Since the thermopile response is faster than the platinum thermocouple assembly, automatic control of furnace temperature has been simplified and the regulation improved.

Finishing Processes

In hot rolling processes, conditions requiring some form of control include metal temperature at the start, during and at the finish of rolling, cooling rate after rolling, and product dimensions.

Metal temperature before rolling is often assumed to be that of the soaking zone of the heating furnace. This can be a safe assumption if ample time is used to heat the material and there is little delay from furnace to start of rolling. If the heating capacity of the furnace limits the operating rate of the mill, it is necessary to measure the temperature of the material leaving the furnace if it is to behave properly in the rolling mill. The optical pyrometer has been widely used for such a duty, but it requires a skilled operator, and most plants have now installed photo-electric or radiation pyrometer recorders.

These new instruments are very rugged and reliable; they are capable of measuring temperatures within ½ to 2 sec., and since they do not require contact with the hot metal, they can be located to view the steel as it is brought to, or as it leaves the mill. The steel leaving the heating furnace is usually covered with scale, and this must be removed (ordinarily with a scale breaker and hydraulic water) before it is viewed by the first pyrometer.

It is of course necessary that the steel be sufficiently hot *during* rolling, as well as at the start. In the past, cooling rates have been determined largely by occasional spot checking with a portable contact pyrometer. Recent improvements in both photo-electric and radiation pyrometers now allow them to register satisfactorily much lower temperatures than formerly and they are suitable even for installation on cooling beds, hot-strip coilers, and in similar situations. These high speed pyrometers have been installed in blooming mills, bar and billet mills, seamless tube mills, welded tube mills, rod mills, merchant mills and strip mills.

Emphasis has been placed on the necessity

for *indirect* control in metallurgical processes. However, one situation to which *direct* control can be applied is the regulation of product dimensions. The recent development of noncontacting thickness gages using X-ray absorption as the means of measurement allows the operator to determine the thickness of rolled sections continuously as they are being produced. The next step should be the automatic control of section thickness by interlinking mill adjustments with the thickness gage. Its application to hot mills is so recent that only a few plants are using it but the steel industry is following the progress of these installations with interest. Figure 2 shows one of these gages mounted on a hot strip mill.

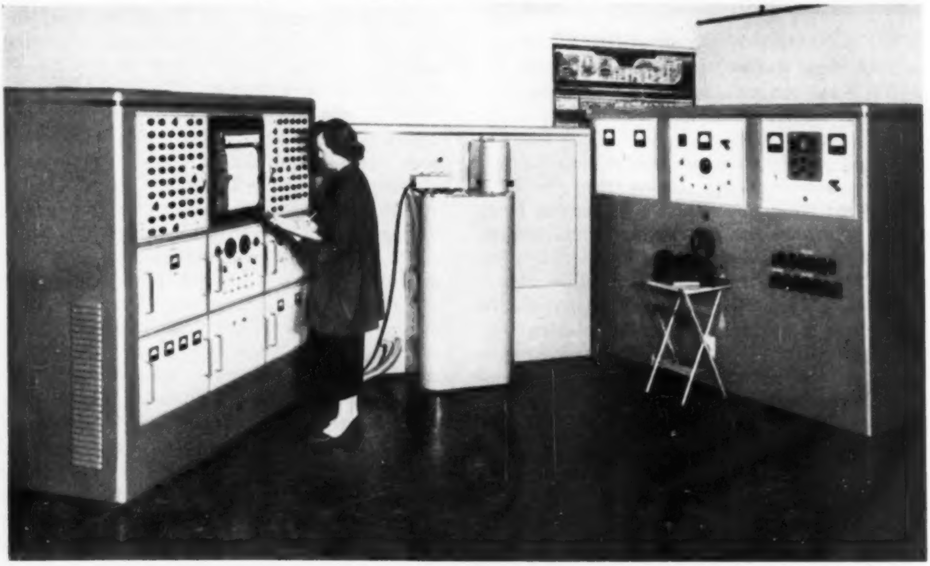
Measurement of Chemical Composition

In the mechanical industries, products are sold on the basis of chemical composition (as well as physical properties) and therefore the determination of composition is an important adjunct to process control. In any event the raw materials must be analyzed. The molten bath is sampled during refining and the necessary adjustments made to obtain the proper composition. Later the composition of the rolled product is checked and finally the finished material is analyzed to insure that the product meets the customer's specifications. The demands on the routine chemical laboratory include speed as well as accuracy. Gravimetric techniques are slow and the chemist has sought more rapid methods. In some instances, the time has been reduced by locating the laboratory close to the process. In others, special instruments have been devised for the rapid determination of critical elements. Examples of such equipment are the magnetic analyzers for carbon that are in almost universal use in steel melting shops. With such instruments carbon can be determined in 2 to 3 min., including the time required for casting the sample — not much more than the ancient scheme of breaking the test ingot and judging the fracture.

Another step toward greater speed of analysis has been the substitution of colorimetric techniques for gravimetric methods. This has followed the perfection of the photo-electric photometer and the photo-electric spectrophotometer.

Of the rapid methods of analysis, the one creating the greatest interest at the present time is the direct-reading spectrograph. This instrument, a model which is shown in Fig. 3, can analyze a sample for as many as ten elements in a minute or less and give the results on direct-reading dials or on a recorder. The principal demand for this instrument has come from the

Fig. 3 — Direct-Reading Spectrograph for Analyzing for Ten Elements in 50 Sec. Courtesy H. F. Beeghly and Journal *of the Electrochemical Society*



aluminum and the alloy steel industries; application in carbon steel plants is somewhat limited since the instrument does not measure carbon or sulphur, and phosphorus can be determined only under special conditions.

With the growing number of metal compositions and special metal treatments in use, correct identification is becoming more difficult. This problem is particularly serious in warehouses and fabricating plants that carry large stocks of materials. The usual method for separating mixed metals is chemical analysis but this is expensive, time consuming, and destructive. Several instruments designed specifically for the separation of mixed metals have appeared on the market; some make only small scratches or indentations on the test material while others are totally nondestructive. They depend on such physical characteristics of the metal as its hardness, magnetic properties, thermo-electric effect, its frictional electromotive force, or its electrical resistance.

Material Testing

Progress in the testing field has been primarily in the direction of more convenient, reliable and speedier instruments. In this general category is the electronic stress-strain recorder for tensile machines, where precision and rapid response are the principal gains. The newer fatigue testing machines allow better control over the conditions of loading and the high-speed, air-driven fatigue instruments, popular in the turbine and jet engine fields, are capable of shortening the testing time to a small fraction of that previously required. In the design of modern hardness testers, convenience, speed of operation and (in some cases) portability have been given consideration. Adaptors and special fixtures are available for most hardness testing equipment so that they are usable on a wide range of shapes, sizes and kinds of material.

Without a doubt, the outstanding development in the field of testing has been the electrical resistance strain gage. Because of its simplicity and almost universal applicability, it has made possible the detailed stress analysis of most engineering structures. The gage itself, as is doubtless well known, consists of a fine wire grid mounted between two layers of thin paper. The resulting assembly is cemented to the surface of the member to be tested and wired to an electrical recorder and current source. After the cement has set, strains applied to the test member, parallel to the wire axis, stretch the wire and vary its electrical resistance. This change is measured and converted to strain in the surface of the test member.

(For convenience, the equipment may be also arranged to indicate strain directly in terms of micro-inches per inch.)

Such gages are available in a variety of gage-lengths and styles. Multiple gages, with more than one gage axis, are used to determine both direction and amount of strain. While most of them have been used at ordinary temperatures, they have also been designed for high temperature testing and, in these applications, the wire is imbedded in a ceramic form and attached to the member with ceramic adhesives. Dynamic as well as static strain measurements can be made. For dynamic work, electronic amplifiers and cathode-ray oscillograph or magnetic-oscillograph recorders are used. The latter instrument is constructed in models containing from one to 36 channels, so that strains from as many as three dozen gages can be recorded simultaneously. Strain gages with multi-channel recorders have found their greatest use in the flight testing of aircraft. For some experiments on expendable missiles, the indications can be radioed to ground stations for recording.

Product Inspection

The war years saw increasing activity in the use of special methods for the inspection of semifinished and finished products. Magnetic detection of cracks and seams in cold finished bars became more precise by the development of improved magnetic particle testing, which was also made more convenient by the use of production line methods. The liquid penetrant technique for the detection of flaws in non-magnetic metals was improved by liquids that would fluoresce under ultraviolet radiation, or by liquids which would color a subsequent coating, sprayed or painted on.

X-rays for metal inspection became commonplace on ordnance material. In order to adapt the method to thicker metal sections, higher voltage X-ray machines were designed and these culminated in the two-million-volt equipment available today. Even higher potentials were considered desirable but very large equipment would be necessary. This situation was circumvented by adapting the small betatron for generation of X-rays of six million volts.

Ultrasonics has also become a valuable tool for the inspection of metals. Used with a radar-like technique, it is possible to detect deep-seated cracks and porosity in forged, rolled and cast metals. It has been applied to the routine

inspection of forgings, billets and completed machine members. In addition to its use in product inspection, it has become popular as a maintenance tool for the detection of fatigue cracks or hidden flaws in axles, crank pins, shafts and other machine parts. In many instances it is possible to apply the test without disassembling the equipment.

Metallurgical Research and Investigation

Of the new tools available to the metallurgical investigator the electron microscope, the electron diffraction equipment and the direct-reading X-ray spectrometer appear to offer the most promise.

Fig. 4 — Direct-Reading X-Ray Spectrometer. Courtesy Applied Research Laboratories

Application of the electron microscope to the field of metallurgy has been retarded somewhat because surface replicas, transparent to electrons, must be used in the microscope rather than the actual metallurgical specimen under study. However, better methods of producing replicas are being devised.

Increased attention to surface reactions and the mechanisms of metal corrosion and protection has aroused interest in the possibilities of electron diffraction for the study of such surface conditions.

The direct-reading X-ray spectrometer, a model of which is shown in Fig. 4, below, has brought increased speed, accuracy and simplicity to X-ray diffraction work. These instruments have been in widespread use in scientific laboratories for the study of crystal structure and the identification of chemical compounds.

Future Trends

While present-day instrument development is moving at a rapid pace, all indications point to greater activity in the near future. High grade ores are becoming scarcer, and research on the beneficiation of lower grade ores is increasing and, with the development of improved ore concentrating processes, it is expected that new instruments for the control of these processes will appear. Considerable attention is being given to problems associated with metal refining. With the present interest in continuous melting and casting processes, it is likely that much new control instrumentation, tailored to the needs of the melting processes, will emerge. The variety and complexity of finishing processes, the desire for inexpensive methods of product inspection and the continuing demand for uniformity of product — all act to stimulate the production of new instruments.

With the aid of the advertising fraternity the term "electronics" has come to be synonymous with the word "progress". In most instances the emphasis has been correctly placed. Electronic techniques have contributed greatly to modern instrumentation. However, recent announcements indicate that electronics may receive some competition, for new instruments employing rugged magnetic amplifiers are coming into use. This amplifying medium consists primarily of metal-cored coils and dry-disk rectifiers. A byproduct of research into naval fire-control instruments, it promises to simplify industrial electric controls, increase their reliability and reduce maintenance. Its ruggedness and lack of sensitivity to ambient conditions such as mechanical shock, humidity and chemical dust should give it unlimited opportunity.

While future progress in metallurgical instrumentation cannot be predicted with certainty, the direction that such progress is taking is clear. Quoting E. H. Howell of the General Electric Co.: "Man has barely started on the task of developing instruments that will give him accurate measurements — for anything conceivable that he wants to measure — and perform automatically thousands of jobs that now take hours of his time."

Reported by
Sidney W. Poole
Metallurgical Department
Republic Steel Corp.
Canton, Ohio

Progress in Electric Steelmaking

AT THE MEETING of the American Institute of Mining and Metallurgical Engineers' Electric Furnace Steel Committee held in Pittsburgh early in December, the use of iron ore in electric furnace steel melting was discussed by A. K. Blough of Republic Steel Corp. Large variations in the silica content (from 10 to nearly 30%), which differ considerably from reported mean silica contents, can cause difficulties with slag control and refractory life. This iron ore variability has improved in recent years. However, the use of sinter, roll scale and scarfing scale is usually preferred as charge material because of their higher iron oxide content and greater degree of uniformity.

Scrap — The subject of scrap and scrap preparation received considerable attention at this conference and was discussed in some detail from the viewpoints of availability, condition and contamination by R. J. McCurdy and R. W. Farley, also of Republic Steel Corp. The goal of the electric furnace is to achieve complete versatility in the production of all grades and qualities as required in any emergency. This depends in large measure on good charging, fast melting, reliable chemical control and melt-down, and freedom from contamination. These factors are all related to scrap supply. Since success of the electric furnace in the melting of all grades depends primarily on fast melting, the density of the scrap is all-important. Its size and weight distribution must be such as to give maximum heat absorption by concentrating the heat *in* the charge, permitting high power input without damage to refractories. Furthermore, the average density of the scrap must be high enough so the furnace can be charged in the least possible time and fewest back charges.

Today, scrap segregation is practically mandatory because of the undesired effects of alloying upon carbon and alloy steels not requiring a particular element; secondly, existing alloying elements must be conserved.

Workers within the mill must be taught to keep the scrap segregated all the way into the furnace, to keep a sharp watch for contaminants, to load for maximum density and uniform charging box cubage per charge, and to charge furnaces for maximum melting rate and safety to equipment and personnel.

One serious type of scrap contamination is concerned with the drastic effects of minor amounts of lead on the hot workability of the austenitic nickel-chromium stainless grades. Amounts as low as 0.004% can cause surface checking. One case reported at this meeting was concerned with a stainless nickel-chromium heat contaminated with 0.051% lead and 0.185% tin; severe surface breaking occurred during reduction to 4 x 4 billets.

Slag materials and slag action in basic arc furnaces were reviewed by C. B. Post and D. G. Schoffstall of Carpenter Steel Co. A new approach was presented to the problem of eliminating oxygen in the steel by the action of reducing slags in the basic electric furnace. This oxygen elimination is dependent upon a function Z which is a ratio between the factors of the absolute forward rate of the $FeO+CaC_2$ reaction in the slag and the specific diffusion rate of FeO from metal to slag. The higher the value of Z, the less the slag wets the metal and the more slowly the oxygen is transferred from metal to slag. Low values of Z mean a rapid rate of transfer of oxygen from bath to slag. The authors feel that the reducing slags high in carbide do not wet the metal sufficiently to be good deoxidizers. On analysis a good, liquid, "faint carbide" slag will contain 55 to 60% CaO, 15 to 25% SiO_2, 10 to 15% CaF_2, and about 10% MgO. For low-

(Continued on page 102)

Personal Mention

Burnie Lee Benbow

Howard S. Avery

Elmer Gammeter

Burnie Lee Benbow, for 41 years with the Cleveland Wire Works (Euclid, Ohio) of the General Electric Co., has retired. He has been manager of the Wire Works for 37 of those 41 years and has seen it grow from a relatively small operation to the leading producer of tungsten specialties, such as fine wire used for filaments and electrodes of incandescent and electric discharge lamps, and the employer of more than 600 trained workers. Early in his career, when both were first being recognized, Mr. Benbow introduced metallographic and advanced testing methods to control production quality and cost. A succession of young men have been given their first boost by him toward an education and an engineering career; much of the American metallurgical literature on tungsten and its alloys and compounds has been produced by men who have worked at Cleveland Wire Works under Benbow's dynamic direction.

Martin D. Vrabel, a recent graduate of the University of Pittsburgh, has accepted a position as metallurgical engineer for wire and rolling mill products at Columbia Steel Co., Pittsburg, Calif.

P. B. Dennis, of the 1950 graduating class of the University of British Columbia, has joined the engineering staff of Atlas Steels, Ltd., Welland, Ont.

The 1950 Lincoln Gold Medal of the American Welding Society was awarded to **Howard S. Avery** for his paper "Hot Hardness of Hard Facing Alloys", which was published in the July issue of the *Welding Journal*. Mr. Avery is research metallurgist with the American Brake Shoe Co., which he joined in 1934 after several years of mining and geology in Mexico, steel mill experience and teaching. He has been chiefly interested in heat and wear resistant alloys and his many technical publications reflect this interest. For years a member of the Alloy Casting Institute's Technical Research Committee, and its chairman from 1947 to 1948, his current interest in the hard facing technique has led to the present researches and the award-winning paper.

Herbert Robinson has been appointed director of the Los Angeles service laboratory of the A. O. Smith Corp.

Warren L. Larson, who recently received his doctor's degree from Massachusetts Institute of Technology, has been appointed metallurgist in research and development department magnesium laboratories, Dow Chemical Co., Midland, Mich.

Gordon H. Silver, formerly chief metallurgist, Monarch Machine Tool Co., Sidney, Ohio, is now manager of the Paul Sobel Co., in New York City.

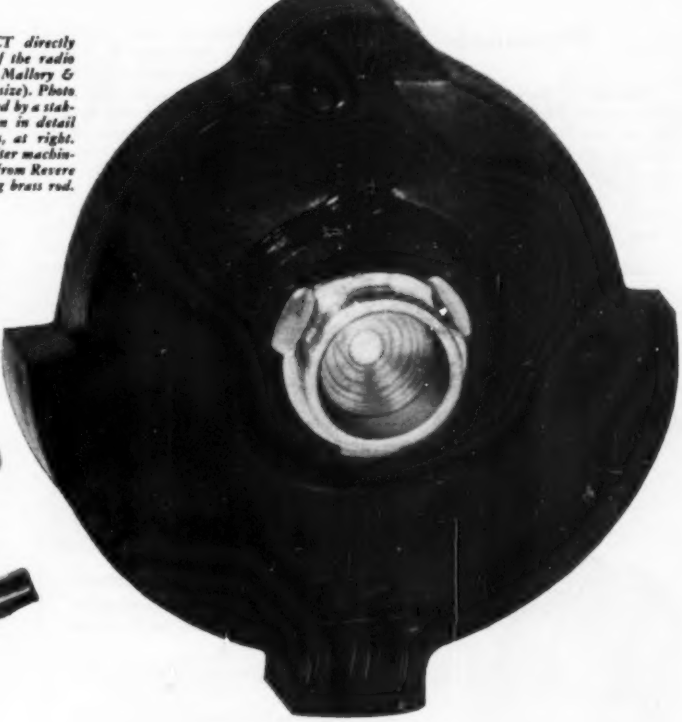
Elmer Gammeter, a national trustee of the American Society for Metals, has recently been named director of laboratories for Globe Steel Tubes Co., Milwaukee. Chief metallurgist since 1943, Mr. Gammeter came to Globe from Carnegie-Illinois Steel Corp., where he was manager of the stainless steel metallurgical bureau. He is a graduate of the Missouri School of Mines and also obtained his M.S. degree from that college. Besides his trusteeship with the ASM, Mr. Gammeter is an active associate of the American Institute of Mining and Metallurgical Engineers, the American Society for Testing Materials and the American Iron and Steel Institute.

The Carbide and Carbon Chemicals Div., Union Carbide and Carbon Corp., announces the following appointments to its Oak Ridge, Tenn., staff: **Anton de Sales Brasunas**, formerly at Massachusetts Institute of Technology, has been named metallurgist and **Richard J. Beaver**, formerly at the University of Kentucky, has been made associate metallurgist.

The Bessemer Medal for 1951 of the British Iron and Steel Institute is to be awarded to **Ben Fairless**, president of the United States Steel Corp., and the Sir Robert Hadfield Medal to **William Barr** of Colvilles, Ltd., president of the West of Scotland Iron and Steel Institute.

John H. Eyler, who received his B.S. from the University of Pittsburgh in 1950, has joined the National Carbon Research Laboratories, Cleveland, Ohio.

THE MUSHROOM-LIKE OBJECT directly below is the completed assembly of the radio volume control shaft made by P. R. Mallory & Co., Inc., Indianapolis, Ind., (actual size). Photo below it shows the plastic part attached by a staking operation. This staking is shown in detail in photo of part enlarged 7 times, at right. Photo at bottom shows control shaft after machining and before staking. Shaft is made from Revere Alloy 247 . . . ¼" round free cutting brass rod.



BY SWITCHING TO REVERE FREE CUTTING BRASS ROD P. R. MALLORY & CO., INC.,

SAVES ON 2 COUNTS!

Staking operation on radio volume control shaft performed without fracture . . . annealing operation eliminated.

The solution to the Mallory Company's problem was not as easy as it might appear. It was not simply a case of Revere Technical Advisory Service recommending ¼" round, free cutting brass rod. That rod had to possess the machinability to match Mallory's existing production machine set-up and at the same time be sufficiently workable so that annealing, prior to staking, could be eliminated; and that staking be accomplished without fracturing the metal.

After consulting with the Mallory Engineers, and discussing the tests which Mallory would subsequently conduct, Revere recommended a ¼" round, half hard riveting and turning rod mixture 247. Working tests made by Mallory showed this rod to possess all the necessary requirements.

As a result of those tests, P. R. Mallory & Company is now using this Revere free cutting brass rod to its complete satisfaction for the radio volume control shafts it manufactures. Not just any ¼" brass rod, but the *right* rod made it possible for them to save on 2 counts.

Perhaps Revere has a brass, a copper or some special alloy to help you in the development or improvement of your product . . . in cutting your production costs. So why not tell Revere *your* metal problems? Call the Revere Sales Office nearest you today.

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Personals

Harold A. Maloney ⊕, past-chairman of the Saginaw Valley Chapter of the American Society for Metals, and formerly plant metallurgist of the Buick Motor Div., General Motors Corp., has been named plant metallurgist of the Transmission Div. of Clark Equipment Co., Jackson, Mich.

John H. Corson ⊕ has recently become associated with the engineering staff of the Bethlehem Steel Co.'s wire rope plant, Williamsport, Pa.

Hyatt Bearings Div., General Motors Corp., Harrison, N. J., announces the appointment of **Fred C. Freeman** ⊕, a recent graduate from Lafayette College, as metallurgist in training and **Allan R. Pfluger** ⊕, recently of Rensselaer Polytechnic Institute, as a metallurgist.

Hugh Wainwright ⊕, **Louis W. Roberts**, **Richard M. Walker** and **Vess Chigas** have formed Microwave Associates, Inc., Boston, Mass., to provide consulting, design and manufacturing facilities for electronic components and equipment.

O. O. Miller ⊕ has recently been appointed research metallurgist at the research laboratory of International Nickel Co., Bayonne, N. J. Dr. Miller held a similar post with the research laboratories of the United States Steel Corp. for the past eleven years.

Benjamin Lajevsky ⊕ is now junior metallurgist with the Glenn L. Martin Co.'s quality control laboratory in Baltimore, Md.

Frederick Stirbl ⊕, formerly metallurgical consultant for the Cooper Alloy Foundry Co., Hillside, N. J., has been appointed staff metallurgical analyst for H. E. Pinkerton & Co., Oyster Bay, N. Y.

Correction: The December issue of *Metal Progress* carried a notice about R. F. Thomson in which it was wrongly stated that he was head of the metallurgical department of the Research Laboratories, General Motors Corp. Mr. Thomson is assistant head; A. L. Boegehold remains head of the department.

Charles A. Conlin ⊕ has just returned from Japan where he was an industrial engineer in the ferrous metals group of the economic and scientific section of S.C.A.P. and he will go into consultant engineering, acting as agent for Japanese steel companies in procuring equipment, materials, and personnel and in performing other services.

Herbert F. Krohn ⊕, formerly contact metallurgist with Bethlehem Steel Co., has been appointed assistant metallurgical supervisor of the laboratories and scrap inspection department of the same company.

James P. Pettid ⊕ is now a pharmaceutical chemist with Dr. LeGear Medicine Co., St. Louis, Mo.

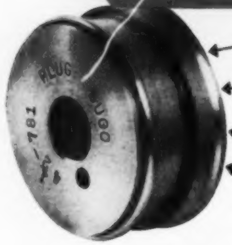
Joseph R. Powell ⊕, formerly with the Scovill Mfg. Co. and the A. S. Campbell Co., is now a chemical sales engineer for Lewis Chemical Co., Inc., Boston, Mass.

Stuart T. Ross ⊕, who received his Ph.D. from Purdue University in June, is now metallurgist and assistant to the chief chemist, Harrison Radiator Div., General Motors Corp., Lockport, N. Y.

James H. Roy ⊕ is now employed by Columbia Steel Co. of Pittsburg, Calif., as metallurgist in the sheet and tin mill.

Michael J. Savitski ⊕ is now an assistant professor of mechanical engineering at the University of Dayton, Dayton, Ohio.

Why Do More Than 100 Leading Firms Use Sentry HARDENING METHODS?



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REASON MAXIMUM HARDNESS!

The methodical growth in the adaptation of the SENTRY DIAMOND BLOCK METHOD of heat treating high speed steel has been based on improved tools, practical economy and efficiency.

Prove for yourself what more than 100 leading firms already know . . . let SENTRY test-harden tools for you; then compare the results in actual tool performance!

Sentry Model 2Y For small tools, cutters of moly, tungsten and cobalt high speed steels.

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Sentry Model YP Vertical model for long, slender drills, reamers, broaches, etc.

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INDUSTRIAL ELECTRIC FURNACES AND EQUIPMENT FOR HEAT TREATMENT OF METALS

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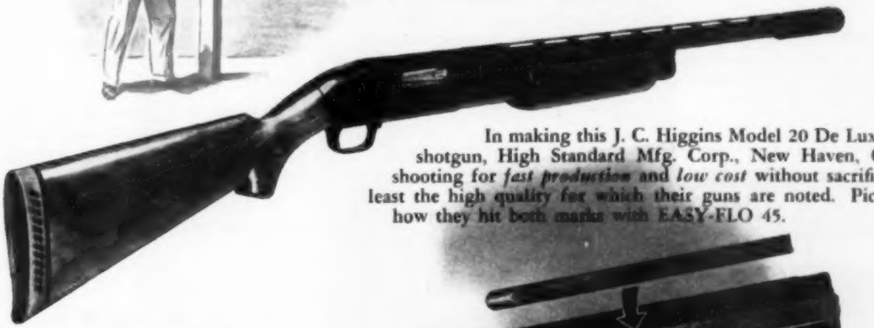
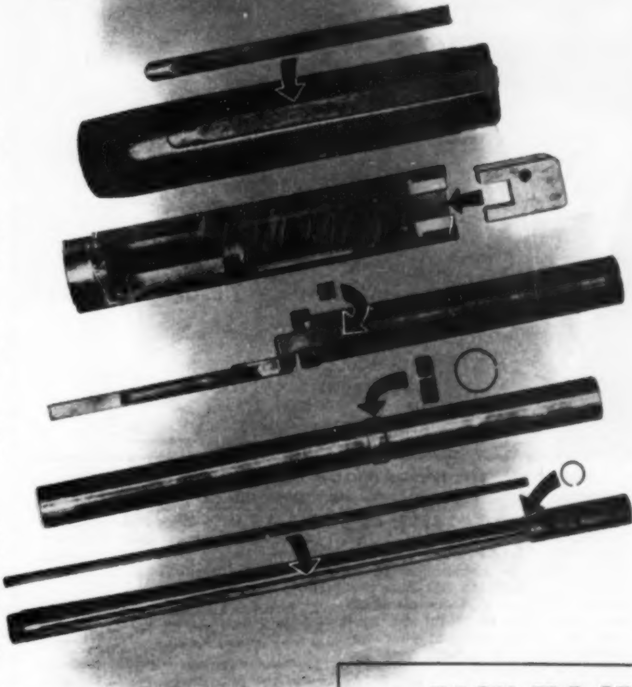
...A picture story of some Good Shooting!



In making this J. C. Higgins Model 20 De Luxe 12 gauge shotgun, High Standard Mfg. Corp., New Haven, Conn., was shooting for *fast production* and *low cost* without sacrificing in the least the high quality for which their guns are noted. Pictures show how they hit both marks with EASY-FLO 45.



RIB brazed to RECEIVER by induction with a piece of .0034" EASY-FLO 45 flat stock preplaced between parts — *time, 25 seconds.*

REAR BLOCK brazed to RECEIVER by induction, with 4 pieces of .070 EASY-FLO 45 wire preplaced—*time, 28 seconds.*

ACTION BAR brazed to FORE-HAND TUBE by induction, with a piece of .015 EASY-FLO flat stock preplaced — *time 5 seconds.*

COLLAR brazed to MAGAZINE TUBE by induction, with a ring of .025" EASY-FLO 45 wire preplaced —*time 5 seconds.*

VENTILATED RIB and COMPENSATOR joined to BARREL with a length of EASY-FLO 45 flat stock staked to under side of rib, and a ring of .031" EASY-FLO 45 wire preplaced in an inside groove in compensator—all brazed in a controlled atmosphere furnace, 6 at a time in 15 minutes or 2½ *minutes per assembly.*

SCORE — 5 neat, strong assemblies in a total time of 3 minutes 33 seconds — with a fraction of an ounce of alloy per joint and no finishing needed — which is good shooting when you're gunning for speed and economy.

WILL EASY-FLO 45 BETTER YOUR SCORE?

Will this remarkable low-temperature silver brazing alloy bring down metal joining costs for you, as it has for hundreds of other manufacturers? Without obligation, we'll send a field engineer to go over your work and give you the answer. Just write or call and say when. For the facts in print WRITE TODAY FOR THE NEW BULLETIN 20.

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Personals

Richard M. Treco, formerly on the staff of Massachusetts Institute of Technology, has recently accepted a position as senior metallurgical engineer in the research laboratories of Sylvania Electric Products Inc., Bayside, N. Y.

Edmond J. Whittenberger is now employed as a research metallurgist in the Cleveland research division of the Aluminum Co. of America.

United States Steel Corp. announces the promotion of **John J. Golden** from steel production division superintendent of the Gary, Ind., works to assistant to the vice-president in Pittsburgh. **Oscar Pearson** will be the new division superintendent at Gary. He was formerly chief metallurgist of the plant.

Following completion of his training course with Wheeling Steel Corp., **Norbert J. Bates** has been assigned to the north works in Steubenville, Ohio, as openhearth metallurgist.

MILNE'S COMPLETE LINE OF HOLLOW AND SOLID TOOL STEELS HAVE OVERALL COLOR IDENTIFICATION THAT SIMPLIFIES INVENTORY CONTROL

MILNE'S TOOL STEELS ARE "UNFORGETABLE" BECAUSE THEY'RE KOLORKOTED – The entire length of the steel is spray painted an identifying color for permanent, quick-as-a-glance identification. Each piece of Milne tool steel keeps on telling you and your employees what it is. Milne's steels are practically confusion-proof.

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With Milne Tool Steels you *can't forget what you get or how to treat it as long as you have it.*

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Westinghouse Electric Corp. announces the appointment of **Martin F. Quaely**, a recent graduate from Trinity College, and **Robert Archer**, a recent graduate from the Polytechnic Institute of Brooklyn, as members of its research staff working on rare metals.

M. W. Williams, formerly foundry manager of the Hughes Tool Co., is now president of the recently organized Industrial Foundry Corp., Houston, Texas.

Benjamin F. Kubilius has been appointed to the staff of research for materials at the Springfield Armory, Springfield, Mass.

W. H. McCarty, Jr., formerly metallurgist at the Lynn River Works, General Electric Co., is now sales metallurgist of Latrobe Electric Steel Co. in the Boston district.

Daniel E. McCarthy has resigned his position with the American Car & Foundry Co. to become standards engineer in the materials and process division of Sperry Gyroscope Co., Great Neck, Long Island, N. Y.

John H. Hoke, previously with the research laboratories of the Rustless Div., Armco Steel Corp., has joined the teaching staff of Johns Hopkins University's School of Engineering, Baltimore, Md.

Warren L. Larson, who recently received his doctor's degree from Massachusetts Institute of Technology, has been appointed metallurgist in research and development department of the magnesium laboratories, Dow Chemical Co., Midland, Mich.

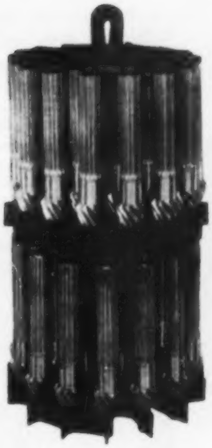
Alexander Zekany is now metallurgist for Rohr Aircraft Corp., Chula Vista, Calif.

George P. Lenz and **John W. Schlendorf** have formed Cardinal Steel Supply Co., Cleveland, which will specialize in hot and cold rolled sheet and strip steel. Both men were previously associated with Nottingham Steel Co., Mr. Schlendorf as vice-president and Mr. Lenz as assistant manager of sales.

Harris M. Sullivan has been elected vice-president and director of research and development of Central Scientific Co. Dr. Sullivan has been with the company since 1944 as assistant director of research.

Geo. H. Thurston has left Hall-Scott Motors, Berkeley, Calif., where he was plant metallurgist and is now at the Benicia Arsenal, Benicia, Calif., in a similar capacity.

JOB PROVEN IN INDUSTRY



ENGINEERED FOR THE JOB:

48 PINIONS — 1248 lbs. WEIGHT — 317 lbs. ALLOY

THIS CHRISTMAS TREE pit-type carburizing fixture was designed for use at Allis-Chalmers Mfg. Co., Springfield, Illinois, to give them *maximum* loading of parts with *minimum* weight of alloy. Entire load and alloy fixture quenched direct from carburizing temperature into oil.

•

Every alloy application must be ENGINEERED for the job—plus the employment of the most advanced foundry technique—to assure the user maximum life—minimum operating expense.

NOTE THESE OUTSTANDING CHARACTERISTICS:

- 4 to 1 loading ratio providing optimum production.
- Lifting eye cast as an integral part of the post eliminating premature failures which result from conventional welded-in pins.
- Elimination of circumferential ribs which tear themselves apart.
- Uniform sections throughout to provide perfect quenching characteristics.
- Full radii of rib surfaces to prevent incipient crack encountered with square edges.
- Versatility of loading.
- Provides uniform quenching of parts and minimum distortion.

ALLOY ENGINEERING & CASTING COMPANY

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HEAT RESISTANT CASTINGS
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Muffles • Retorts • Belts • Chain • Roller Rails • Trays & Fixtures • Salt Pots

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

Annealing Ti and Zr

(Continued from p. 69)

ready for further processing immediately.

Recently one of the producers of titanium brought us some 0.020-in. wire which it was stated could not be drawn any further. The wire had been air annealed a number of times and the surface was seriously contaminated. However, after the material was vacuum annealed it was drawn to 0.007 in. in a series of 20 to 30% drafts (three intermediate vacuum anneals) without difficulty and could have been taken much further if required. It is not meant to imply that vacuum annealing will cure the embrittling effect caused by the absorption of nitrogen and oxygen; in this wire, contamination had not gone so far as to embrittle the material completely. If the wire had been vacuum annealed from a section size of perhaps $\frac{1}{8}$ in. in diameter on down, a much finer and more ductile product would have resulted.

Pickling — A nitric-hydrofluoric acid pickling solution composed of 10% nitric acid (42° Baumé) and 2% hydrofluoric acid (60%) by volume is quite effective in removing light discoloration but this solution is ineffective on heavily scaled parts. Molten caustic (sodium hydroxide) is useful for removing heavy nitride-oxide scale produced by air annealing but does not do a complete job and fails to remove the contaminated underlying metal. Furthermore, a violent reaction with a caustic bath has recently been reported, apparently traceable to electrolytic action between titanium and a heat resisting alloy basket in which it was contained.

Sodium hydride has the disadvantage of introducing large quantities of hydrogen into the metal, as the hydride bath operates in a temperature range in which both titanium and zirconium show a peak in their rate of hydrogen absorption. It has taken us as long as 24 hr. to pump the hydrogen out of hydride-pickled titanium during annealing in a vacuum furnace.

Summary — It would appear that these conclusions are justified:

1. The effect of annealing these reactive metals in active gas (air or controlled atmosphere) is to produce not only the expected scaling of the part but also a surface hardening of the metal which cannot be eliminated by de-scaling or pickling.

(Continued on page 102)

Reports from all types of foundries show ROTOBLAST saves up to $10,000 a year and MORE!

ROTOBLAST saves labor—industry's biggest single cost item. In each of the three typical ROTOBLAST cases tabulated below, *savings on labor* averaged well over a $100 a week. In addition, cleaning took less time and power costs decreased.

Save with ROTOBLAST

ROTOBLAST UNIT	CASH SAVED	NAME OF USER
Table-Room	**$11,102** on labor alone	Lewistown Foundry, Lewistown, Pa.
Room	**$10,160** on labor alone	Harris-Seybold, Cleveland, Ohio
Barrel	**$5,080** on labor alone	Yates-American Machine Co., Beloit, Wisconsin

If you want savings like this, specify Pangborn ROTOBLAST. Whether you clean castings or forgings, grey iron, brass or steel, you'll find ROTOBLAST saves money and speeds up cleaning with no sacrifice in quality!

ROTOBLAST

- **SAVES LABOR:** One ROTOBLAST machine and operator can do as much as a two-man crew and old-fashioned equipment.
- **SAVES SPACE:** In many cases, one ROTOBLAST machine replaces five or more old-fashioned machines, requires less space.
- **SAVES TIME:** Cases on record prove ROTOBLAST can cut cleaning time up to 95.8% compared with old-style methods.
- **SAVES POWER:** Modern ROTOBLAST uses but 15-20 h.p. compared to old-fashioned equipment requiring 120 h.p. for same job.
- **SAVES TOOLS:** On work cleaned with ROTOBLAST, cutting tools last up to 2/3 longer because no scale is left to dull edges.

. . . and these savings mean INCREASED PROFITS for you!

ROTOBLAST* ... Cleans These Intricate Castings for 2¢ EACH!

An actual case report from Garden City Foundry, Stoughton, Wisconsin

"Reduced our cleaning costs!" says superintendent John Selgrath about Garden City's ROTOBLAST team of Table and Barrel. Costs on two intricate flywheel castings back up his statement. The smaller 31 lb. piece is cleaned by the ROTOBLAST Table shown above for only *2c each!* Larger 49 lb. flywheels are cleaned in the Barrel for just 5.3c each—and both figures include *all labor, power and operating costs!*

But that's not all. Breakage used to seriously hamper production, but no more. Cleaning is faster too, and now Garden City states it can give its customers *any finish they want!*

IF YOU WANT TO CUT COSTS TOO, find out about Pangborn ROTOBLAST. There's a ROTOBLAST Table, Barrel, Table-Room and Monorail Cabinet for every blast cleaning job. To find out how modern Pangborn ROTOBLAST equipment can save you money, send for Bulletin 214. It contains valuable specifications, performance data and photographs. For your copy, write today to: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Maryland.

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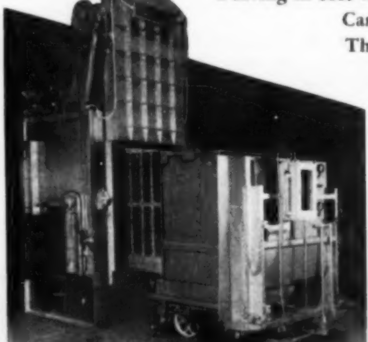
Write for Bulletin HD-664



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DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

MILWAUKEE 1, WISCONSIN

Annealing Ti and Zr

(Starts on page 69)

2. Inert atmosphere protects against such effects but is quite expensive, particularly for large parts or long, thin parts (wire or tube).

3. Vacuum annealing appears to be best practice for light parts, from the standpoints of both quality and economy.

4. Pickling of heavily scaled objects is very difficult and the most practical method so far devised is de-scaling in molten caustic. Unfortunately the caustic treatment entails some dangers which have not yet been thoroughly studied.

Electric Steel

(Continued from page 93)

carbon, low-alloy, and stainless steels, slags of the following composition are preferred: 50 to 60% CaO, 20 to 30% SiO_2, 10 to 20% CaF_2, and about 10% MgO.

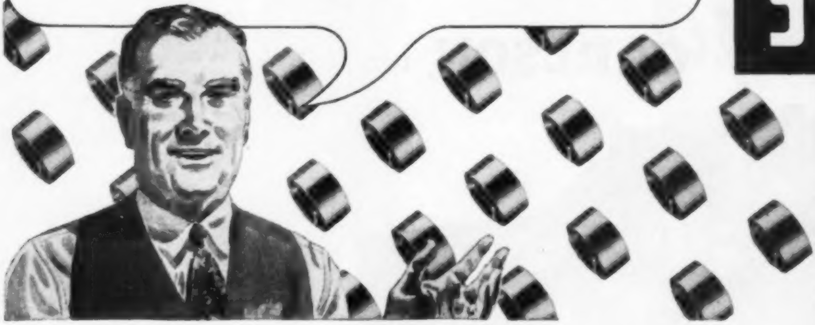
Refractories — In a discussion on the control of refractory materials, C. E. Sumpter of Carnegie-Illinois Steel Corp. stated that silica brick (with low initial cost and performance) is better on a cost-per-ton basis, with few exceptions, than any other type for roof construction. However, it has sometimes become necessary to use other roof refractories of higher melting point. Of particular interest are trials of a 13½-in. mullite-base brick in a furnace roof that produces only stainless steel. Some 10% of the production by this furnace has been 0.03% max. carbon austenitic stainless, and extremely high temperatures are required to make it. Life obtained with this roof was more than three times that obtained with 18-in. silica roofs. The ultimate failure of the roof was attributed to structural spalling rather than loss through melting.

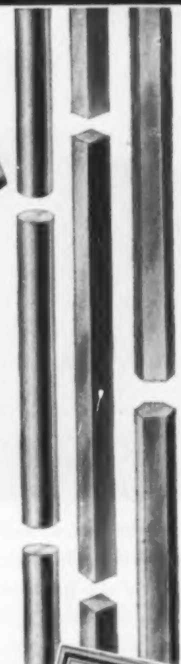
Continuous Casting

A large attendance at a session on continuous casting was evidence of the considerable interest in the subject. As pointed out by Isaac Harter, Jr., engineer in charge of the project at Babcock and Wilcox Tube Co.'s plant in Beaver Falls, Pa., the concept is not new; indeed the inventive genius of Sir Henry Bessemer was concerned with the problem of continuous casting and he obtained a patent for his developments in this field. *(Cont. on p.104)*

WE INCREASED PRODUCTION
71% WITH J&L "E" STEEL

J&L STEEL





(a story* about how to win customers and influence prospects)

"Got a minute? Well, let me tell you about what happened at our machine shop a couple of months ago when we first tried that new J&L "E" Steel. You wouldn't believe it was possible! (Confidentially, neither did we until we proved it to ourselves.) Here's what happened.

"We got an order to produce a big lot of plunger stops for solenoid starter switches. They're tricky to run, and you've got to be pretty careful every second. We'd read about "E" Steel in some of J&L's ads, and decided we might try some on this job.

"So we ordered some 17/32" E-33 "E" Steel stock, set up our B&S #2 and B&S #0 Automatics and began to turn out parts. We had used B-1113 for this job before and had been getting 350 pieces per hour. But we soon realized we could machine much faster with "E" Steel, and **we kept increasing speed until we were getting an average of 600 parts per hour. That's a 71% production increase!**

"Next thing we discovered was that our tools were lasting twice as long and the chips were coming off better with "E" Steel than they did with B-1113. We also found that the finish on the parts had improved from 20% to 25%.

"That's why we've been using "E" Steel. We turn out work much faster and can take on more jobs. Our men like the way "E" Steel machines and our customers get better parts and better service. Everybody benefits!"

Get your copy of the booklet titled "A Progress Report on 'E' Steel." It outlines a series of 11 case histories from machine shops that have used "E" Steel with excellent results. Write for your copy.

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Electric Steel

(Starts on page 93)

The basic considerations involved with the continuous casting of steel are

1. Composition.
2. Pouring temperature.
3. Slag separation before the steel enters the mold.
4. Proper mold design, which involves facilities for the very rapid removal of heat.
5. Automatic pouring control.
6. Proper casting shape and cross section.

In pouring from a top charge, 7-ton electric furnace, a top pouring tun-dish is used with an inverted weir to separate the slag. Steel entering the mold must be slag-free to prevent defective surfaces on the finished product. The brass mold must be capable of thermal transfer rates 50 times those prevailing in a boiler tube, and this involves a water flow in the cooling sections at about a mile a minute. A casting with oval section, having a large surface-to-weight ratio, has been found most desirable.

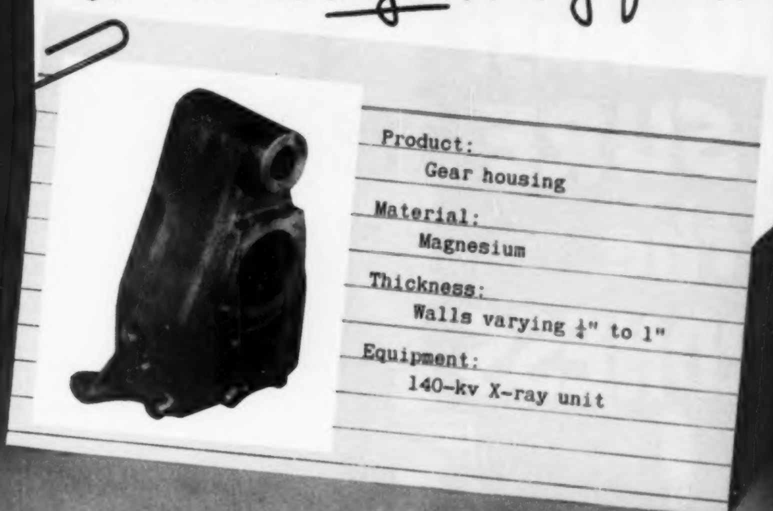
Practically all the discussion on this topic concerned the casting of a plain steel containing 0.10 to 0.20% carbon, 0.30 to 0.60% manganese. However, some stainless steel has been cast by continuous methods, as well as a 0.75 to 0.85% carbon, 0.70 to 0.90% manganese grade and A.I.S.I. 52100 steel. In 1947 Babcock and Wilcox Tube Co., in cooperation with Republic Steel Corp., produced 600 tons of continuously cast steel. The product of one experimental run involved the piercing of 173 pieces of tubing of which only one was rejected for an outside seam. This certainly is indicative of good quality for piercing and forging applications.

Several of the advantages of continuous casting are:

1. It delivers a very high per cent of sound metal to the finishing operations.
2. Pound loss on croppage is considerably less than with conventional ingot practice.
3. It bypasses ingot production and soaking pit and blooming mill operations — a major advantage in over-all economics.

Continuous casting can be applied to about one quarter of the steel industry's tonnage. The low capital investment and its high yield potentialities make it an attractive investment for small, nonintegrated plants. *(Continued on page 106)*

What's the right X-Ray film?

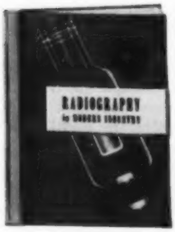


ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE M

In a light alloy casting such as this, the radiographer is interested in discovering microporosity, as well as other irregularities that might be present. This requires the highest possible visibility of detail.

Therefore, Kodak Industrial X-ray Film, Type M, is chosen because this film has the highest contrast and finest graininess of all x-ray films.



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Basic Electric Steel

(Starts on page 93)

C. Taylor, of Armco Steel Corp., discussed some physico-chemical aspects of electric furnace steel melting and the increased difficulty of hitting the required analysis among the numerous and complex grades of steel now being produced. The use of nomographs for calculating additions of chromium to the A.I.S.I. stainless Type 304 was illustrated. As pointed out in the discussion by D. Gherardi of Timken Steel and Tube Division, many steel specifications are now so exacting that complete cooperation between meltshop supervision and the metallurgist is essential.

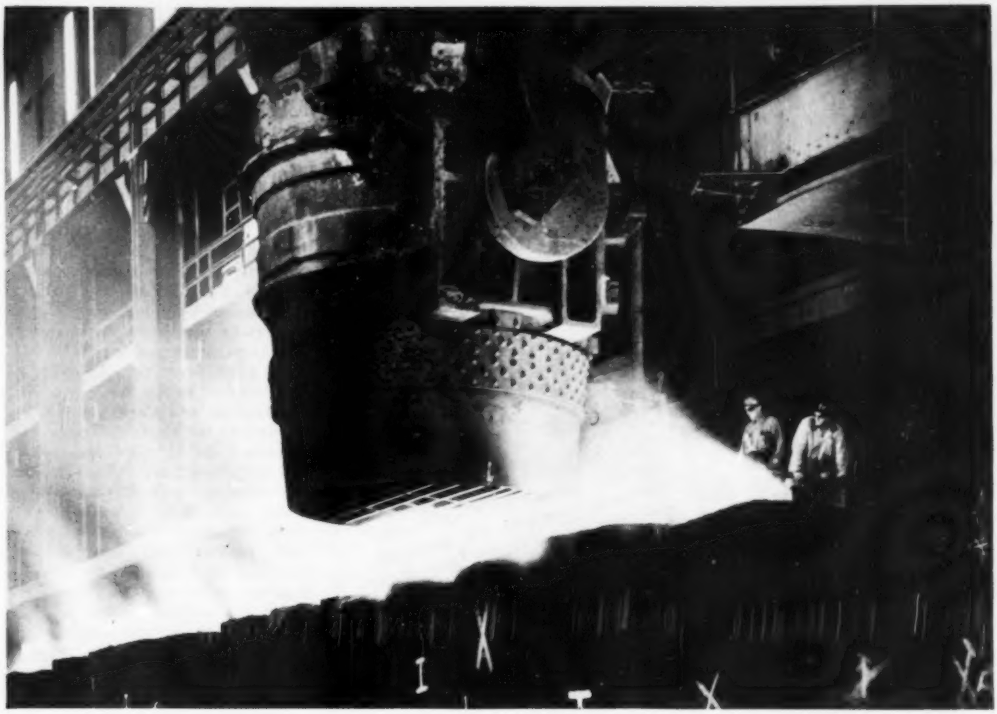
Practical aspects of toolsteel melting were next discussed by C. F. Sawyer, Jr., of Vanadium-Alloys Steel Co. Most of the highly alloyed types are dead melted. Steels such as 18-4-1 are not usually slagged off after melt-down, unless an excessive slag volume is present. When this happens the slag is turned from oxidizing to reducing before the excess is removed, so any chromium and vanadium oxidized during melting are not lost. The low-carbon, highly alloyed, hot work die steels present problems not encountered with higher carbon grades. These steels are dead melted in the same way as the high speed types, but the carbon content is about 0.35%. The charge must be properly calculated to melt-in at or slightly below the correct carbon, since boiling down the carbon will lose substantial amounts of tungsten as well as chromium and vanadium. In producing high-tungsten steels a portion of the required tungsten can be supplied by reducing scheelite ($CaWO_4$) ore added to the slag; reducing materials, such as CaC_2 and ferrosilicon, are mixed with the scheelite or with molybdenum oxide before charging. Some difficulties with poor slags are due to scheelite ores high in lime; these result in poor tungsten recovery.

In discussing the melting of simple and compound steels in 50-ton electric furnaces, A. K. Blough of Republic Steel Corp. emphasized the following points:

1. Limit chromium in the charge so that, on melting down, it is within a 0.2 to 0.4% range. This minimizes nonmetallic inclusions.

2. Lime-silica ratios of over 2.5 are desired, together with a good boil during the oxidation period.

(Continued on page 108)



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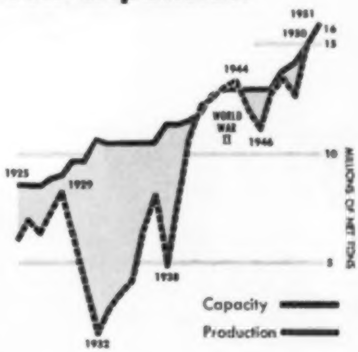

On January 1 of this year Bethlehem's steel making capacity stood at 16 million ingot-tons annually—*an increase of 1 million tons* over a year ago.

Since the war ended we have increased our annual steelmaking capacity *3,100,000 tons, or 24 per cent.*

Moreover, as the chart at the right shows, Bethlehem's steel capacity has nearly doubled in 25 years. Additional capacity can and will be created as it is needed.

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Specialists in Stainless, Low Alloy and Non-Ferrous Electrodes

Electric Steel

(Starts on page 93)

3. Use of reboil: When over 0.30% carbon, reboil with 500 lb. of ferromanganese with 50-ton heats; when under 0.30% carbon, 600 lb. of silicomanganese are used.

4. For final adjustments, the ferro-alloys must be clean.

5. Hot heat at slag-off period: For A.I.S.I. 52100, a slag-off temperature of 2930° F. and a tap temperature of 2780° F. are desired (as determined by platinum-rhodium immersion thermocouples). A falling temperature gradient is considered good practice on all types from slag-off to tap.

Rimming and Carbon Steel production in the electric furnace was discussed by P. Lindberg, Jr., of McLough Steel Corp. When producing rimming steels in 80-ton units, a slag with 18 to 25% FeO is desired. Four thousand heats have been poured with 2-in. nozzles; they are best adapted to the mill practice using 26 x 47 x 72-in. ingot molds. A special pocket block is set in from the outside with a ¼-in. clearance for a nozzle, heavily slurried on the outside, which is set in place with a quarter turn.

Pounds of aluminum for additions to 80-ton rimming heats are calculated by the following formula:

[FeO (in slag before tap) − 14] × 3

One half of this is added in ladle, the balance in each ingot.

Stainless Steel — The major points made by R. J. Wilcox of Michigan Steel Casting in his paper on induction melting of stainless steels (in 1000-lb. units) were the high recoveries of oxidizable elements, particularly 92% recovery of columbium. Production of 18-8 for castings consumed 779 kw-hr. per ton; melting time, 58 min. per 1000-lb. heat; average lining life: 110 heats. Of most interest was the use of selenium for degasification. As a result of considerable experimental effort it was found that a very minor quantity of selenium (0.01%) is extremely effective in the prevention of gas porosity in castings; addition of 0.25 lb. ferroselenium per ton was found to be definite insurance against gas porosity ordinarily experienced from high hydrogen or nitrogen contents.

It was also said in this meeting that tellurium has the same effect, and that selenium also prevents gas porosity when added to the ladle.

In discussing recent developments in melting, *(Cont. on p. 110)*

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Electric Steel

(Starts on page 93)

A. Ogan of Carnegie-Illinois Steel Corp. stated that the current trend is toward greater tonnage, better quality and lower cost. Shortages of nickel and desirable scrap militate against this. There is also apparent a trend to top-charging in stainless melting, and higher power input to speed the melt-down. The use of larger furnaces for melting stainless was emphasized. In discussing stainless with 0.03% max. carbon, Mr. Ogan stated that this has passed the development stage and such heats are now routine. The major consideration in making this grade, as emphasized by J. H. Eisaman, also of Carnegie-Illinois, is extreme care in all details of operation. Many development heats of this grade were made in a 30-ton arc furnace before production began on larger furnaces.

Several other points mentioned by Mr. Ogan were:

1. There is a trend toward the use of aluminum and calcium-silicon on stainless finishing slags in an effort to get cleaner steels. Calcium-silicon as a ladle addition is also becoming more common.

2. Use of sponge titanium has not aided titanium recovery in making Type 321, but has minimized inclusion stringers.

3. "Misch metal" (the rare-earth alloy) is being added experimentally as a ladle deoxidizer for austenitic stainless grades. This alloy is reputed to improve cleanliness and hot workability — particularly of the more highly alloyed austenitic types.

4. It is too early to make predictions with respect to the use of Kellogg hot-topping equipment, utilizing a nonconsumable electrode.

Acid Electric

Meetings on acid electric foundry practice were concerned, for the most part, with the special deoxidizers and temperature control.

Deoxidation in the ladle with "Carbortam" (15 to 21% Ti, 1 to 2% Al, 1 to 2% B, 2 to 4% Si, 4.5 to 7.5% C) was described by W. O. Igleman of National Malleable and Steel Castings Co. His conclusions were that heats for castings requiring no higher pouring temperatures than 2850° F. can be sufficiently deoxidized with this material. Ductility is increased when it is used instead of aluminum, and chain-type inclusions decreased. *(Cont. on p. 112)*

Customer Reports:

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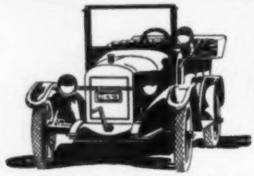

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Electric Steel

(Starts on page 93)

Tempering after normalizing is frequently avoided; metal fluidity is also increased, with a much lower percentage of cracked and misrun castings.

Special deoxidizers were also discussed by C. G. Mickelson of American Steel Foundries. He also mentioned the use of selenium with varying amounts of aluminum, "Graphidox", silicon-magnesium-aluminum, and metallic sodium. These deoxidizers show promise for increasing mechanical properties and ductility, and also influence grain boundary inclusions.

In the general discussion on acid electric practice such factors as the history of the heat, depth of bath, carbon reduction, and hold after boil, were considered to be items which should be evaluated in addition to the specific deoxidizer used, else conclusions may be clouded.

In summarizing this session on special deoxidizers, R. H. Jacoby of Key Co. pointed out that the preponderance of data presented was concerned with correlation of tensile ductility. Not enough work has been done on notch ductility; more data are also needed on effect of deoxidizer on grain size.

A paper on production control of molten steel temperature and its effect on steel casting quality, presented by C. A. Faist of Burnside Steel Foundry, was received with considerable interest. This author concluded that control of steelmaking and pouring temperatures has a decided bearing on the appearance and mechanical properties of steel castings. One of the most striking relationships found in a study of over 400 heats was the interdependency of the mechanical properties of the steel and the tapping temperature. Plots of tapping temperature versus quality factor (P-value) for heat treated castings developed an unusual S-shaped curve, which indicates that there is a very definite critical temperature range wherein the quality factor is adversely affected. Data developed by the author seem to bear out the theory that this characteristic curve is not a function of chemical composition, heat treatment, or of pouring method, but that it is rather a function of the method with which the molten steel originally cools and solidifies in the mold.

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The plating baths consist of common nickel or cobalt salts such as the sulphate or chloride, to which is added phosphorous acid. Solution make-ups are given in the original document. The baths are operated at a low pH — between 0.5 and 1.5, depending on the composition. To maintain the desired acidity in the cathode film, the solution must be buffered; phosphoric acid is one of the best chemicals for this purpose. The plating baths are kept at 165° F. or above; at room temperature the cathode current efficiency is very low and the deposits are weak. At the usual current density (about 0.10 amp. per sq.cm.) the rate of deposition is rather high, amounting to several thousandths inch per hour.

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Hardness of the deposits as plated varies from 350 to 720 on the Vickers scale, increasing with phosphorus content. Heat treated at 750° F. they become much harder. For example, a heat treated 10% phosphorus-cobalt deposit reaches a hardness of over 1100 Vickers, which is greater than that of electrodeposited chromium. Deposits which have been heated as high as 1475° F. and then cooled are not appreciably softer than the initial electrodeposit.

Although the low-phosphorus

(Continued on page 116)

*Abstract of "Electrodeposition of Alloys of Phosphorus and Cobalt or Nickel", by Abner Brenner, Dwight E. Couch, and Eugenia Kellogg Williams, *Journal of Research*, National Bureau of Standards, Vol. 44, 1950, p. 109. Research Paper No. 2061.


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Electroplate

(Continued from page 114)

alloys become ductile after heat treatment at 1475° F., deposits containing more than 1% phosphorus are generally brittle. Alloys of cobalt or nickel with higher percentages of phosphorus are highly resistant to corrosion and chemical attack, exceeding in this respect the pure metals.

Hot Working of Copper and Alloys*

THIS PAPER of 25 pages embraces a thorough review of previously published papers, but is based on work and observations of the authors, who are familiar with the processes. Nine figures and three tables of their own are presented, and 32 references are cited.

Deformation of metal at normal temperatures involves slip planes, with work hardening. Hot work involves plastic flow, without work hardening. In general, alpha alloys are less easily hot worked than pure copper, while alpha-plus-beta alloys are easily hot worked. Low-melting impurities of limited solubility, such as lead or bismuth, or low-melting compounds, impair the hot workability of the alpha alloys more than of the alpha-beta type. A sound, fine-grained casting is usually workable over a wider temperature range than one of coarse grain, especially in the presence of unsoundness or insoluble impurities.

Piercing of tube billets is the severest hot working test, because of tension stresses, while extrusion allows wide latitude. Hot rolling is intermediate. Two tables give the initial temperature ranges for hot rolling and extrusion of coppers and common alloys.

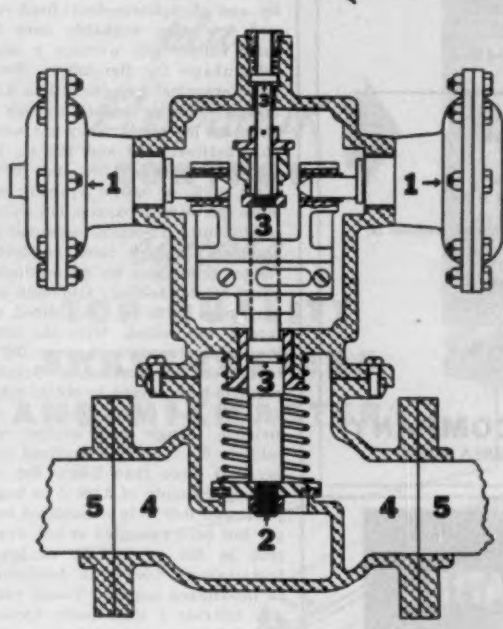
Care and experience are necessary in predicting hot workability from laboratory tests. Hot bend tests are useful. Hot torsion tests are especially good when the metal is to be pierced. Finally, hot forging tests are indicative of the hot rolling properties.

Tough pitch high-conductivity copper is hot workable over a wide temperature range. Slabs are often

(Continued on page 118)

*Abstracted from "The Hot Working of Copper and Copper Alloys", by Maurice Cook and Edwin Davis, *Journal*, Institute of Metals (London), Vol. 76, 1950, p. 501.

here's the "INSIDE STORY"



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Hot Working of Copper and Alloys

(Continued from page 116)

rolled in the lower ranges, to prevent excessive scaling, and wire bars may be rolled from 4 x 4-in. cross section down to ¼ in., starting at about 850° C. Oxygen-free high-conductivity and phosphorus-deoxidized coppers are also workable over the same range with perhaps a slight advantage for the latter. Tough pitch arsenical coppers, 0.3 to 0.5% arsenic, require higher oxygen to maintain the pitch. They are workable between 800 and 900° C., but hot short between 600 and 700° C. With 0.5% or more arsenic and more than 0.05% oxygen, hot rolling is difficult. Phosphorus-deoxidized arsenical coppers have no brittle range. Silver has no appreciable effect on hot rolling. Cadmium and chromium up to 1%, deoxidized, are readily hot rolled. With the latter the temperature is kept above 700° C. to prevent age hardening. Sulphur requires high oxygen to obtain pitch, and the hot rolling range is restricted. Tough pitch copper will tolerate 0.5% lead; deoxidized copper, not more than 0.02% for hot rolling. Bismuth of 0.006% in tough pitch and 0.01% in deoxidized copper has been recorded as hot workable at 800 to 900° C.; at lower temperatures 0.002% is deleterious in deoxidized copper. Tough pitch will tolerate a little more because some of it may be oxidized.

The alpha alloys of copper-zinc are hot worked from 65 to 97% copper. Lead up to 0.025% may be tolerated in hot rolling, but a lower figure is usual. Arsenic and antimony up to 0.05% are used in extruded tubes. Bismuth must be kept below 0.005%.

The copper-zinc alloys in the alpha-plus-beta and beta fields are most easily hot workable (56 to 63% copper). Additions of lead, tin, silicon, nickel, iron, aluminum and manganese are usual. Only lead affects hot rolling and the tolerance for this is much greater than in alpha brass.

Cupro-nickels from 0 to 30% nickel are readily hot workable. Deleterious impurities are lead, carbon, sulphur and oxygen. Nickel silvers in the alpha range are similar to alpha brasses; in the alpha-plus-beta and beta ranges, they resemble corresponding brasses. Aluminum bronzes, in both alpha and beta phases, resemble brasses.

(Continued on page 120)

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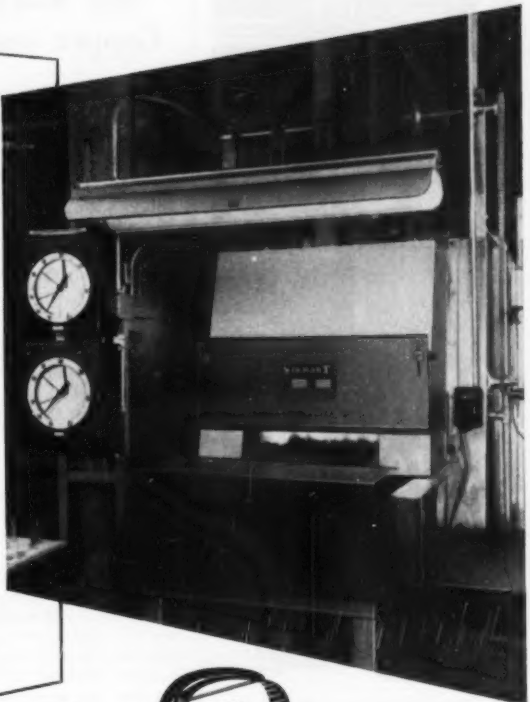

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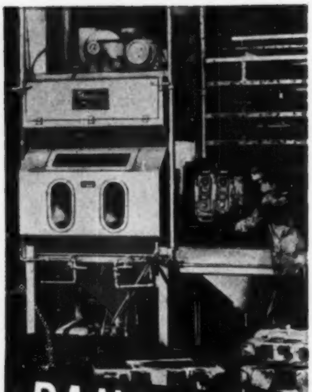
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Hot Working of Copper and Alloys

(Continued from page 118)

Silicon bronzes are easily hot workable with lead restricted to about 0.05%.

Copper and various grades of brass, such as 60-40, naval brass, silicon bronze and cupro-nickel, are universally broken down hot and sometimes finished hot if plates or sheets are produced. The alpha brasses are increasingly broken down hot in large ingots for finishing cold in strip.

Extrusion is widely used for rods, tubes and sections. The alpha and beta alloys are most easily extrudable, but the process is increasingly used for cupro-nickels, tin bronzes, aluminum bronzes, nickel silvers and silicon bronzes. A brief review of extrusion presses is given and a table showing the properties of some of the commonly extruded brasses.

Rotary piercing is used extensively for making copper shells and somewhat for the alpha brasses and the alpha-plus-beta brasses. The operation is described. The severe stresses involved require metal of the best hot working properties.

Hot forging is described briefly. The brasses of alpha-plus-beta and beta types are most frequently used.

Abstracter's Remarks—If any criticism were to be offered, it would be that too much weight has been given to previously published data. Such a criticism might be unjust, for the authors' citations of literature are undoubtedly included so that the reader can make his own discounts. Wherever the authors write from their own experience, I find myself in entire agreement with them. But I find difficulty in believing that deoxidized copper can be hot rolled, commercially, with as much as 0.02% lead or 0.01% bismuth. The statement that tough pitch copper will tolerate 0.5% lead for hot rolling purposes really ought to be qualified by explaining that this depends on its being present as lead oxide. In the same vein, I would not wish to undertake the hot rolling of alpha brasses with as much as 0.025% lead or silicon bronzes with 0.05% lead. These statements appear in print from time to time, perhaps for lack of more exact published information. One could wish that such sound and seasoned brass men as the authors had cited them more critically.

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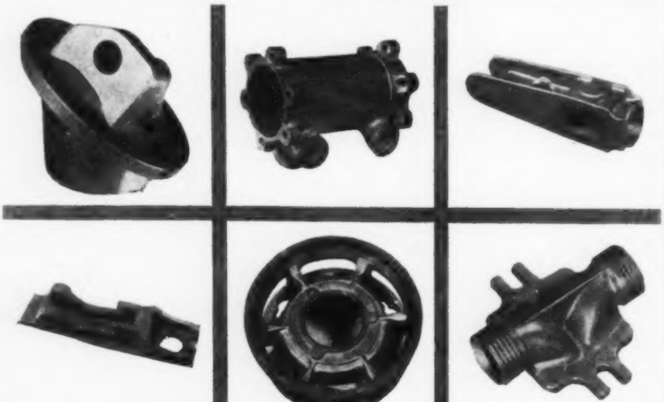

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A—Induction melting furnace

B—Electrically heated launder

C—Induction holding and pumping unit

D—Pump nozzle

E—Cold chamber of die casting machine

Photo courtesy of Scintilla Magneto Div., Bendix Aviation Corp.

Streamlined Molten Metal Supply by AJAX

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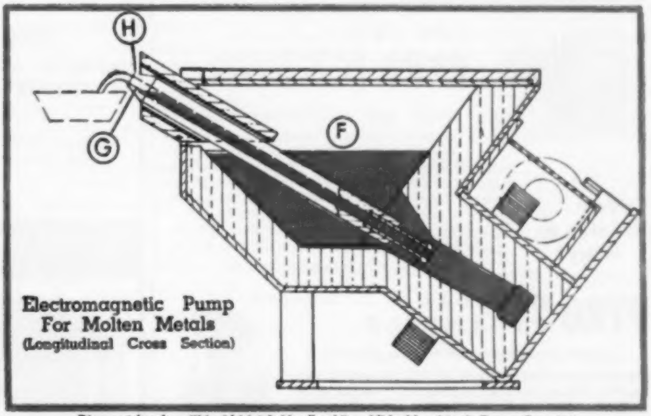

Electromagnetic Pump For Molten Metals (Longitudinal Cross Section)

Diagram taken from "Liquid Metals Handbook", published by Atomic Energy Commission

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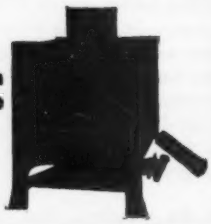

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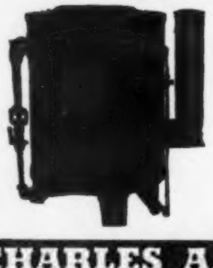

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2. Select sub-group which best fits application
3. Note major tool characteristics (under arrow) and other characteristics in cut-outs for each grade in sub-group
4. Select tool steel indicated

That's all there is to it!

Here's an example:

Application—Deep drawing die for steel

Major Class—Metal Forming—Cold

Sub-Group — Special Purpose

Tool Characteristics—Wear Resistance

Tool Steel—Airdi 150

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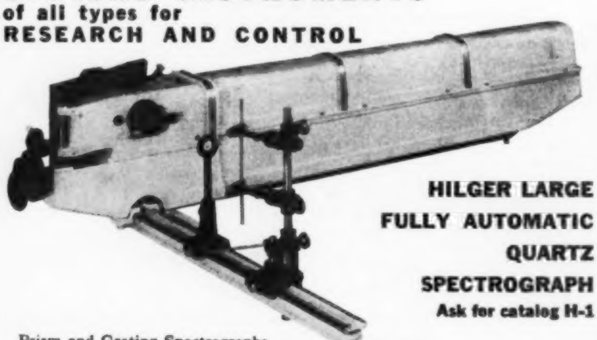

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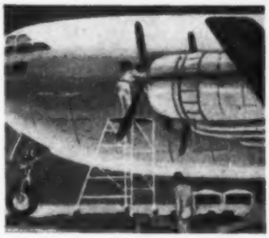

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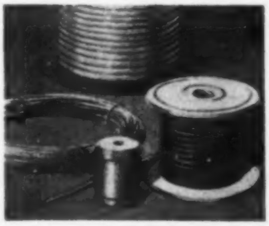

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Lucas 0185

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Furnaces, Car-Type

American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Despatch Oven Co.
Drever Co.
Electric Furnace Co.
Gordon Co., Claud S.
Hagan Co., Geo. J.
Harper Electric Furnace Corp.
Hevi Duty Electric Co.
Holcroft Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Copper Brazing

Ajax Electric Co.
American Gas Furnace Co.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Hevi Duty Electric Co.
Holcroft Co.
Hones, Inc., Charles A.
Hoskins Mfg. Co.
Ipsen Industries, Inc.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, Electric Heat Treating

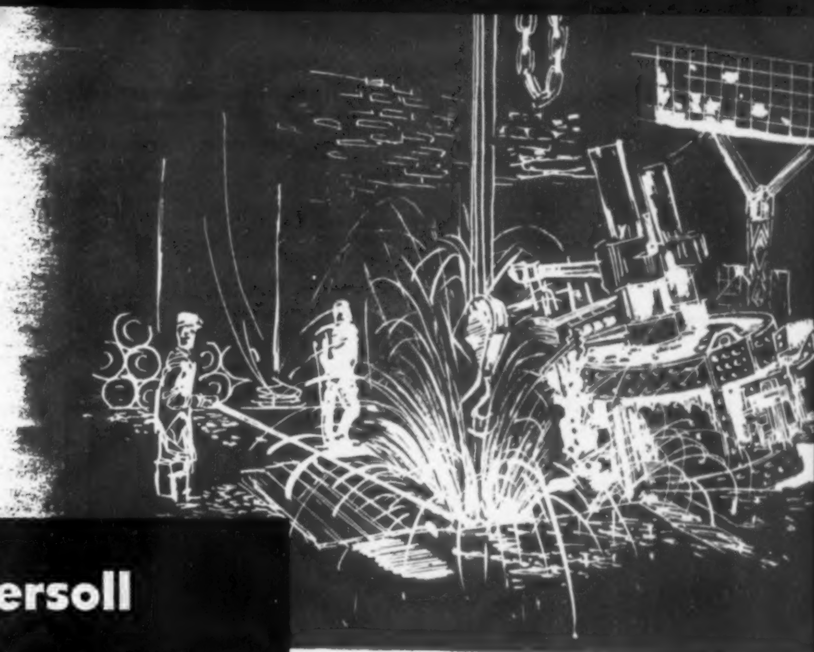
Ajax Electric Co.
Ajax Electrothermic Corp.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Despatch Oven Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Hagan Co., Geo. J.
Harper Electric Furnace Corp.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Holden Co., A. F.
Hoskins Mfg. Co.
Ipsen Industries, Inc.
Leeds & Northrup Co.
Lindberg Eng. Co.
Loftus Eng. Corp.
Ohio Crankshaft Co.
Rockwell Co., W. S.
Sentry Co.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, Electric Steel Melting

Ajax Electrothermic Corp.
American Bridge Co.
Gordon Co., Claud S.
Ohio Crankshaft Co.
Rockwell Co., W. S.

Furnaces, Forging

Ajax Electric Co.
Ajax Electrothermic Corp.
American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.



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Harper Electric Furnace Corp.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Loftus Eng. Corp.
Ohio Crankshaft Co.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Gray Iron Melting

Ajax Electrothermic Corp.
American Bridge Co.
Gordon Co., Claud S.

Furnaces, Heat Treating (Cyanide or Lead)

Ajax Electric Co.
American Gas Furnace Co.
Continental Industrial Engrs., Inc.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Hones, Inc., Charles A.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sentry Co.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Heat Treating (Gas)

American Gas Furnace Co.
Baker & Co., Inc.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Delaware Tool Steel Corp.
Despatch Oven Co.
Dow Furnace Co.
Drever Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.
Hagan Co., Geo. J.
Holcroft Co.
Hones, Inc., Charles A.
Ipsen Industries, Inc.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Heat Treating (Oil or Gas)

American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Despatch Oven Co.
Drever Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.
Hagan Co., Geo. J.
Holcroft Co.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, High Speed Steel Hardening

Ajax Electric Co.
American Gas Furnace Co.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Delaware Tool Steel Corp.
Eclipse Fuel Eng. Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Holden Co., A. F.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Heating (Continuous)

Ajax Electric Co.
American Gas Furnace Co.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Delaware Tool Steel Corp.
Eclipse Fuel Eng. Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Holden Co., A. F.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Induction

Ajax Electrothermic Corp.
Ajax Engineering Corp.
Burrell Corp.
Gordon Co., Claud S.
Lepel High Frequency Labs., Inc.
Lindberg Eng. Co.
Ohio Crankshaft Co.
Westinghouse Electric Corp.

Furnaces, Laboratory

Ajax Electrothermic Corp.
Buehler, Ltd.
Burrell Corp.
Central Scientific Co.
Cooley Electric Mfg. Co.
Delaware Tool Steel Corp.
Despatch Oven Co.
Dietert Co., Harry W.
Eberbach & Son Co.
Eclipse Fuel Eng. Co.
Fisher Scientific Co.
Gamma Scientific Co.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Harshaw Chemical Co.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Hones, Inc., Charles A.
Hoskins Mfg. Co.
Lindberg Eng. Co.
Marshall Co., L. H.
National Research Corp.
Precision Scientific Co.
Rockwell Co., W. S.
Sentry Co.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, Nonferrous Melting

Ajax Electrothermic Corp.
Ajax Engineering Corp.
American Bridge Co.
American Gas Furnace Co.
Continental Industrial Engrs., Inc.
Eclipse Fuel Eng. Co.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Holden Co., A. F.
Hones, Inc., Charles A.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Recirculating

American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Despatch Oven Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.
Hagan Co., Geo. J.
Hayes, Inc., C. I.
Holcroft Co.
Ipsen Industries, Inc.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.

Furnaces, Salt Bath

Ajax Electric Co.
Continental Industrial Engrs., Inc.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
Gordon Co., Claud S.
Holcroft Co.
Holden Co., A. F.
Hones, Inc., Charles A.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sentry Co.
Sunbeam Stewart Ind. Furnace Div.

Furnaces, Tempering

Ajax Electric Co.
American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Despatch Oven Co.
Drever Co.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Holden Co., A. F.
Hones, Inc., Charles A.
Ipsen Industries, Inc.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sentry Co.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, Tool and Die Hardening

Ajax Electric Co.
American Gas Furnace Co.
Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Cooley Electric Mfg. Co.
Delaware Tool Steel Corp.
Eclipse Fuel Eng. Co.
Electric Furnace Co.
General Electric Co., Apparatus Dept.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Hones, Inc., Charles A.
Ipsen Industries, Inc.
Leeds & Northrup Co.
Lindberg Eng. Co.
Loftus Eng. Corp.
Rockwell Co., W. S.
Sentry Co.
Sunbeam Stewart Ind. Furnace Div.
Surface Combustion Corp.
Westinghouse Electric Corp.

Furnaces, Tube Combustion Analysis

Burrell Corp.
Cooley Electric Mfg. Co.
Fisher Scientific Co.
Gordon Co., Claud S.
Harper Electric Furnace Corp.
Hevi Duty Electric Co.
Lindberg Eng. Co.
Sentry Co.
Western Gold & Platinum Wks.

Gas Analysis Recorders

Burrell Corp.
Engelhard, Inc., Charles
Leeds & Northrup Co.
Precision Scientific Co.
Rubicon Co.

Generators, Acetylene

Air Reduction Sales Co.
Linde Air Products Co.

Generators, Nitrogen

Baker & Co., Inc.
Continental Industrial Engrs., Inc.
Electric Furnace Co.
Hayes, Inc., C. I.
Holcroft Co.
Ipsen Industries, Inc.
Kemp Mfg. Co., C. M.

Generators, Plating

Chemical Corp.
Columbia Electric Mfg. Co.

Generators, Special Atmosphere

Continental Industrial Engrs., Inc.
Electric Furnace Co.
Hayes, Inc., C. I.
Hevi Duty Electric Co.
Holcroft Co.
Ipsen Industries, Inc.
Kemp Mfg. Co., C. M.
Lindberg Eng. Co.
Rockwell Co., W. S.
Westinghouse Electric Corp.

Gold and Gold Alloys

American Platinum Wks.
Baker & Co., Inc.
Handy & Harman
Western Gold & Platinum Wks.

Graphite

Acheson Colloids Corp.
Internat. Graphite & Electrodes Corp.
National Carbon Div.

Grinding and Polishing Machines

Acme Manufacturing Co.
Buehler, Ltd.
Central Scientific Co.
Gamma Scientific Co.
Gordon Co., Claud S.
Hill Acme Co.
Martindale Electric Co.
Precision Scientific Co.
Ryerson & Son, Inc., Joseph T.

Grinding Machines, Surface

Hill Acme Co.
Norton Co.
Ryerson & Son, Inc., Joseph T.

Grinding Wheels

Norton Co.
Ryerson & Son, Inc., Joseph T.

Hammers, Steam Drop

Erie Foundry Co.

Hardness Testers

American Optical Co.
Ames Precision Machine Wks., Inc.
Buehler, Ltd.
Clark Instrument, Inc.
Detroit Testing Machine Co.
Eberbach & Son Co.
Erb & Gray
Gordon Co., Claud S.
Harshaw Chemical Co.
King Portable Brinell
Newage International, Inc.
Olsen Testing Mach. Co., Tinius
Rubicon Co.
Steel City Testing Machines Co.
Wilson Mechanical Instr. Co., Inc.

Hearths, Refractory

Carborundum Co.
Norton Co.

Heat Exchangers

Bell & Gossett Co.
Chas. T. Brandt, Inc.
Carl-Mayer Corp.
Korn, Inc., Wm.
National Carbon Div.
Norton Co.
Westinghouse Electric Corp.

Heaters, Oil

Bell & Gossett Co.
Despatch Oven Co.
Korn, Inc., Wm.
Rockwell Co., W. S.

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Driver-Harris Co.
Hevi Duty Electric Co.
Kanthal Corp.
Precision Scientific Co.
Western Gold & Platinum Wks.
Westinghouse Electric Corp.

Heating Elements, Radiant Tube

Electric Furnace Co.
Electro-Alloys Div.
Michigan Steel Casting Co.

Induction Heating Machines

Ajax Electrothermic Corp.
Lepel High Frequency Labs., Inc.
Ohio Crankshaft Co.
Westinghouse Electric Corp.

Inert Gas Machines

Continental Industrial Engrs., Inc.
Electric Furnace Co.
Holcroft Co.
Kemp Mfg. Co., C. M.
Linde Air Products Co.
Rockwell Co., W. S.
Westinghouse Electric Corp.

Inhibitors

American Chemical Paint Co.
Barrett Div.
Chemical Corp.
Enthone, Inc.
Northwest Chemical Co.

Inspection Process

Dy-Chek Co.

Instruments, Atmosphere Indicating

Bristol Co.
Eberbach & Son Co.
Engelhard, Inc., Charles
Fisher Scientific Co.
Gordon Co., Claud S.
Martindale Electric Co.
Precision Scientific Co.
Tagliabue Instruments Div.
Westinghouse Electric Corp.

Instruments, Recording

Bristol Co.
Brown Instruments Div.
Engelhard, Inc., Charles
Gordon Co., Claud S.
Leeds & Northrup Co.
Lindberg Eng. Co.
Pyrometer Instrument Co., Inc.
Tagliabue Instruments Div.
Wheelco Instruments Co.

Laboratory Equipment, Chemical

American Platinum Wks.
Burrell Corp.
Central Scientific Co.
Dietert Co., Harry W.
Eberbach & Son Co.
Erb & Gray
Fisher Scientific Co.
Harshaw Chemical Co.
Leitz, Inc., E.
National Spectrographic Labs., Inc.
Precision Scientific Co.
Rubicon Co.

Laboratory Equipment, Metallurgical

Ajax Engineering Corp.
Buehler, Ltd.
Burrell Corp.
Central Scientific Co.
Dietert Co., Harry W.
Eberbach & Son Co.
Erb & Gray
Fisher Scientific Co.
Gordon Co., Claud S.
Harshaw Chemical Co.
Ipsen Industries, Inc.
Lindberg Eng. Co.
National Spectrographic Labs., Inc.
Precision Scientific Co.
Western Gold & Platinum Wks.

Lead

Federated Metals Div.
St. Joseph Lead Co.

Lead Pots

Alloy Engineering & Casting Co.
Chicago Steel Foundry Co.
Driver-Harris Co.
Eclipse Fuel Eng. Co.
Electro-Alloys Div.
General Alloys Co.
Kemp Mfg. Co., C. M.
Michigan Steel Casting Co.
Ohio Steel Foundry Co.
Pressed Steel Co.
Standard Alloy Co.

Lubricants

Acheson Colloids Corp.
American Chemical Paint Co.
Cities Service Oil Co.
Gulf Oil Corp.
Houghton & Co., E. F.
Stuart Oil Co., Ltd., D. A.

Magnetic Testing

Dice Co., J. W.
Rubicon Co.

Magnesium

Aluminum Co. of America
Dow Chemical Co.
Federated Metals Div.

Marking Crayons

Gordon Co., Claud S.
Korn, Inc., Wm.

Metal Cleaning Compounds

American Chemical Paint Co.
Chemical Corp.
Cowles Chemical Co.
Detrex Corp.
Diversey Corp.
Enthone, Inc.
Heatbath Corp.
Houghton & Co., E. F.
Mitchell-Bradford Chem. Co.
Northwest Chemical Co.
Optimus Equipment Co.
Park Chemical Co.

Metal Powders

Handy & Harman
Vanadium-Alloys Steel Co.

Metallographic Equipment

American Optical Co.
Bausch & Lomb Optical Co.
Buehler, Ltd.
Burrell Corp.
Central Scientific Co.
Eberbach & Son Co.
Erb & Gray
Fisher Scientific Co.
Gamma Scientific Co.
Gordon Co., Claud S.
Harshaw Chemical Co.
Jarrell-Ash Co.
Leitz, Inc., E.
National Spectrographic Labs., Inc.
Precision Scientific Co.

Metallurgical Microscopes

Buehler, Ltd.
Burrell Corp.
Eberbach & Son Co.
Erb & Gray
Gamma Scientific Co.
Gordon Co., Claud S.
Harshaw Chemical Co.
Jarrell-Ash Co.
Leitz, Inc., E.
National Spectrographic Labs., Inc.

Meters, Gas or Air

Bristol Co.
Brown Instruments Div.
Illinois Testing Labs., Inc.

Microscopes

American Optical Co.
Bausch & Lomb Optical Co.
Buehler, Ltd.
Burrell Corp.
Central Scientific Co.
Eberbach & Son Co.
Erb & Gray
Gordon Co., Claud S.
Jarrell-Ash Co.
Leitz, Inc., E.
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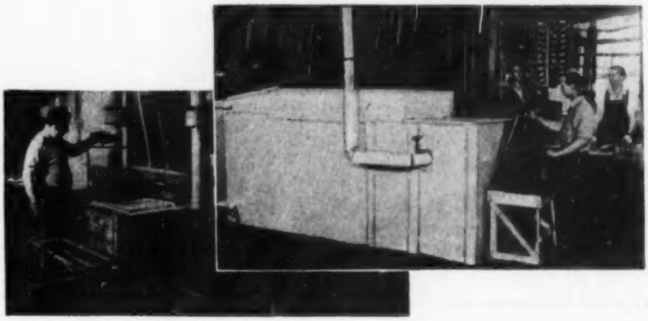

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HEAT TREATING SALTS, CLEANERS, ETC.

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Muffles

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Driver-Harris Co.
Electro-Alloys Div.
General Alloys Co.
Michigan Steel Casting Co.
Norton Co.
Ohio Steel Foundry Co.
Pressed Steel Co.
Rolock Inc.

Nickel and Nickel Alloys

Ampco Metal, Inc.
Carpenter Steel Co.
Chicago Steel Foundry Co.
Driver-Harris Co.
Electro-Alloys Div.
General Alloys Co.
Haynes Stellite Div.
International Nickel Co., Inc.
Ohio Steel Foundry Co.
Revere Copper & Brass Inc.
Riverside Metal Co.

Nozzles, Oxyacetylene

Linde Air Products Co.
Precision Scientific Co.

Nozzles, Sand Blasting

Norton Co.
Pangborn Corp.

Nut Making Machines

National Machinery Co.

Oil Coolers

Bell & Gossett Co.
Korn, Inc., Wm.

Oils, Quenching

Cities Service Oil Co.
Gulf Oil Corp.
Houghton & Co., E. F.
Ipsen Industries, Inc.
Park Chemical Co.
Stuart Oil Co., Ltd., D. A.

Optical Instruments

American Optical Co.
Bausch & Lomb Optical Co.
Eastman Kodak Co.
Erb & Gray
Fisher Scientific Co.
Gordon Co., Claud S.
Harshaw Chemical Co.
Jarrell-Ash Co.
Leitz, Inc., E.
National Spectrographic Labs., Inc.

Ovens, Core and Mold

Carl-Mayer Corp.
Continental Industrial Engrs., Inc.
Despatch Oven Co.
Gordon Co., Claud S.
Holcroft Co.
Rockwell Co., W. S.

Ovens, Laboratory

Burrell Corp.
Carl-Mayer Corp.
Central Scientific Co.
Despatch Oven Co.
Dietert Co., Harry W.
Eberbach & Son Co.
Eclipse Fuel Eng. Co.
Erb & Gray
Fisher Scientific Co.
Gamma Scientific Co.
Gordon Co., Claud S.
Harshaw Chemical Co.
Hayes, Inc., C. I.
Precision Scientific Co.
Rockwell Co., W. S.

Oxygen

Air Reduction Sales Co.
Linde Air Products Co.

Peening, Shot

Pangborn Corp.

Pickling Baskets and Crates

Ampco Metal, Inc.
Chicago Steel Foundry Co.
Michigan Steel Casting Co.
Mitchell-Bradford Chem. Co.
Pressed Steel Co.
Rolock Inc.
Stanwood Corp.

Pickling Compounds

American Chemical Paint Co.
American Cyanamid Co.
Barrett Div.
Chemical Corp.
Diversey Corp.
Houghton & Co., E. F.
Reilly Tar & Chemical Corp.

Pickling Machines

Chemical Corp.
Optimus Equipment Co.
Rockwell Co., W. S.

Pickling Tanks

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Chas. T. Brandt, Inc.
Chemical Corp.
Mitchell-Bradford Chem. Co.
Optimus Equipment Co.
Pressed Steel Co.
Rockwell Co., W. S.
Rolock Inc.

Pipe, Asbestos and Cement

Johns-Manville

Pipe, Brass and Copper

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Revere Copper & Brass Inc.

Pipe, Centrifugally Cast

Electro-Alloys Div.
Michigan Steel Casting Co.
U. S. Pipe & Foundry Co.

Pipe, Corrosion Resistant

Allegheny Ludlum Steel Corp.
Ampco Metal, Inc.
Carpenter Steel Co.
Chicago Steel Foundry Co.
Driver-Harris Co.
Federated Metals Div.
Frasse & Co., Inc., Peter A.
Haynes Stellite Div.
Michigan Steel Casting Co.
National Carbon Div.
Republic Steel Corp.
Revere Copper & Brass Inc.
U. S. Pipe & Foundry Co.

Platers' Cleaning Compounds

Chemical Corp.
Cowles Chemical Co.
Mitchell-Bradford Chem. Co.
Northwest Chemical Co.

Plates

Bethlehem Steel Co.
Carlson, Inc., G. O.
Republic Steel Corp.
U. S. Steel Co.

Platinum and Platinum Alloys

American Platinum Wks.
Baker & Co., Inc.
Western Gold & Platinum Wks.

Plating Equipment

Chemical Corp.
Distillation Products, Inc.
Kinney Mfg. Co.

Polishing Machines

Acme Manufacturing Co.
Buehler, Ltd.
Central Scientific Co.
Precision Scientific Co.

Pots, Lead, Cyanide

Bell & Gossett Co.
Chicago Steel Foundry Co.
Driver-Harris Co.
Eclipse Fuel Eng. Co.
Electro-Alloys Div.
General Alloys Co.
Heatbath Corp.
Kemp Mfg. Co., C. M.
Michigan Steel Casting Co.
Ohio Steel Foundry Co.
Park Chemical Co.
Pressed Steel Co.
Rockwell Co., W. S.

Powder Metal Equipment

Arthur Colton Co. Div.
Electric Furnace Co.
Kux Machine Co.
Lindberg Eng. Co.

Powder Metallurgy Products

Amplex Manufacturing Co.
Moraine Products Div.
Precision Scientific Co.

Precious Metals

American Platinum Wks.
Baker & Co., Inc.
International Nickel Co., Inc.
Western Gold & Platinum Wks.

Pressed Metal Parts

Amplex Manufacturing Co.
Chas. T. Brandt, Inc.
Revere Copper & Brass Inc.

Presses

Baldwin-Lima-Hamilton Corp.
Erie Foundry Co.
Hydropress, Inc.
Kux Machine Co.
Ryerson & Son, Inc., Joseph T.
Verson AllSteel Press Co.

Presses, Forging, Coining

Ajax Manufacturing Co.
Baldwin-Lima-Hamilton Corp.
Erie Foundry Co.
Hydropress, Inc.
National Machinery Co.
Verson AllSteel Press Co.

Presses, Hydraulic

Baldwin-Lima-Hamilton Corp.
Bethlehem Steel Co.
Arthur Colton Co. Div.
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(Left) Flame-hardening gives added service life to parts by providing a hard, wear-resisting surface on a tough, ductile core. (Right) Oxygen-cutting equipment easily slices steel up to 60 in. thick. A 30-in. cut through this 45-in. thick ingot took only 15 minutes.

HELIARC welding in a protective shield of argon or helium gas easily joins hard-to-weld metals such as aluminum, magnesium, stainless steel, and copper alloys. Absence of flux and spatter reduces cleanup and finishing costs.

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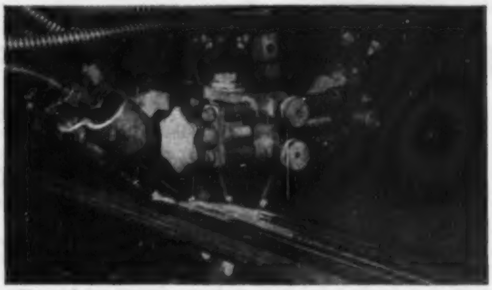

Plate-edge preparation with OXWELD apparatus makes it possible to cut steel plate to size and bevel the edges for welding in one, quick, oxygen-cutting operation.

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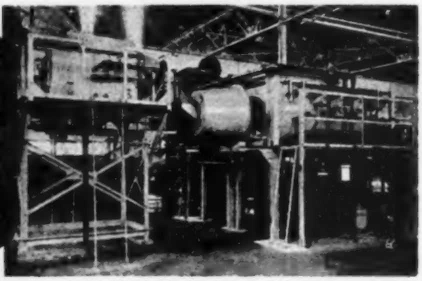

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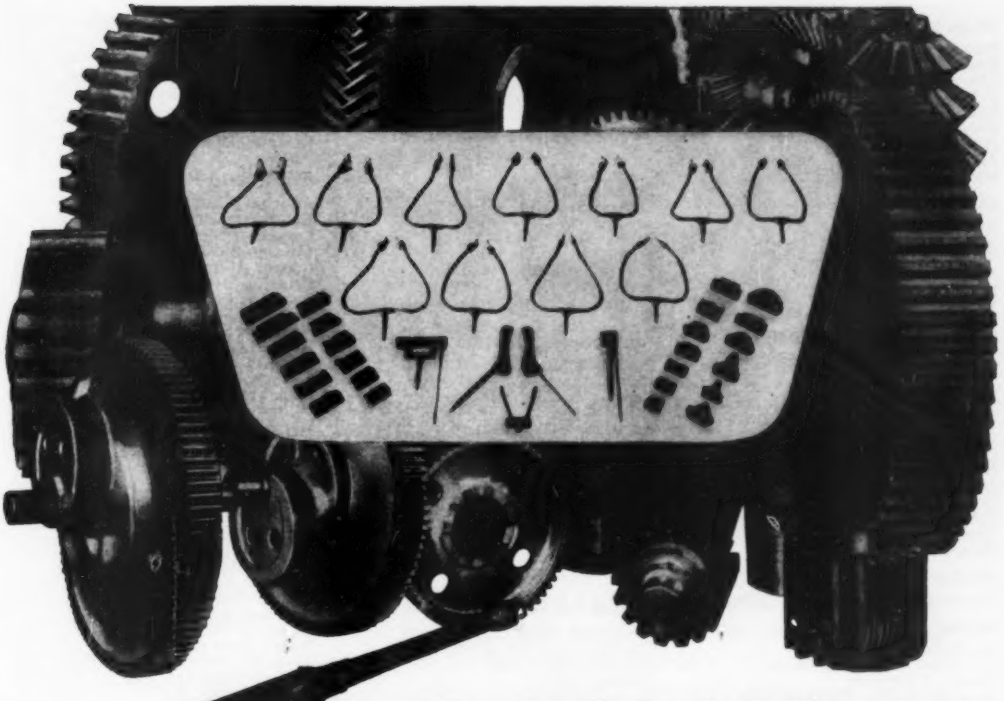

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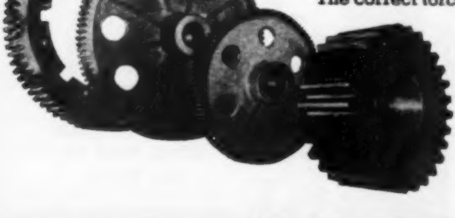

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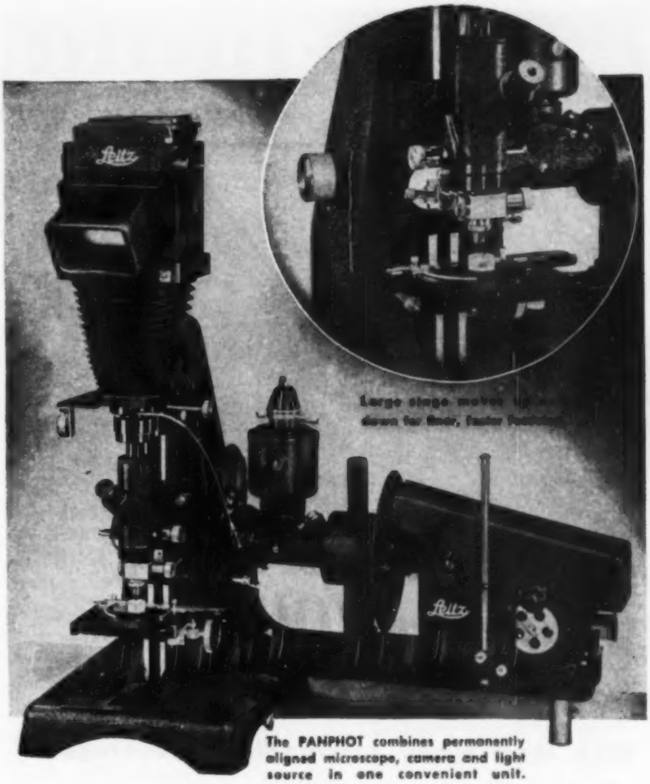

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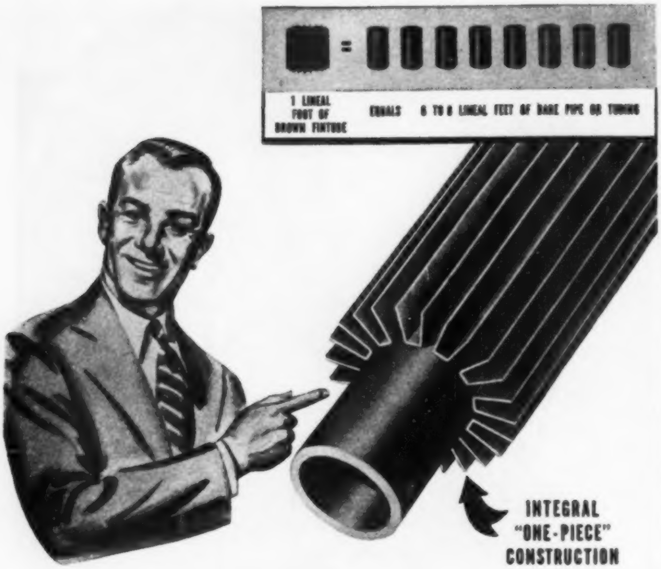

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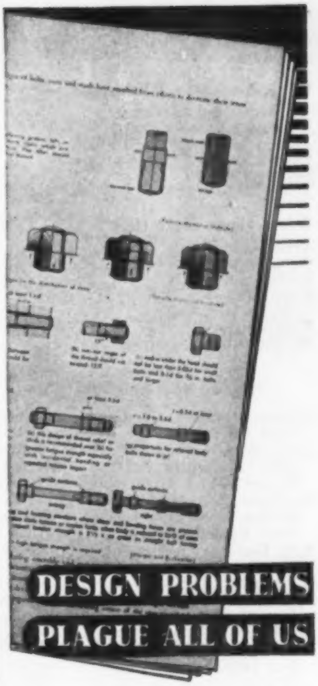

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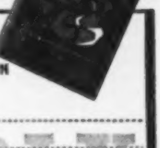

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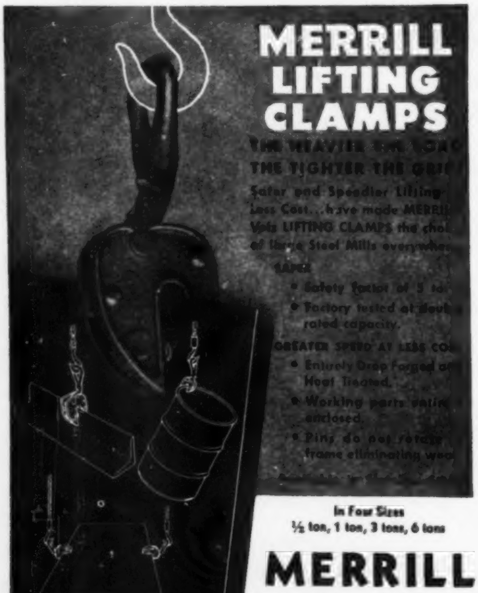

KING PORTABLE BRINELL

HARDNESS TESTER

How many times have you carried heavy work to the Brinell Tester? Too often, you'll say.

Here is a 26-lb. portable tester you can easily take to the work and save time and trouble by doing your Brinell work on the job. The King Portable Brinell puts an actual load of 3000kg on a 10mm ball. It can be used in any position.

Throat—4" deep. Gap—10" high. Weight—26 lbs.

The test head is removable for testing larger pieces beyond the capacity of the standard base.

Let us show you how we can lighten your Brinell testing.

ANDREW KING

NARBERTH, PENNA.

An Arwood Casting Saves 33%

When your product needs peak casting performance, take advantage of Arwood's Quality Control.

The cam illustrated is a typical example of the advantages of precision casting. To manufacture it is a difficult problem in any process, since the track must be smooth, level and parallel with the top surface. Yet Arwood is casting this part in wear resistant beryllium copper at a cost one third less than a machined cam.

Steel die molds assure accurate dimensions and sharp contours.

Metal soundness is assured by X-ray and Magnaflux controls, physical and chemical certifications.

Arwood Precision Investment Casting is now a tested and important method for producing small intricate parts. It has been the answer to many design and production problems and can be the answer to yours.

For additional information about Precision Castings write for our new booklet, "A Critical Survey of Investment Castings".

ARWOOD

PRECISION CASTING CORP.

68 WASHINGTON STREET • BROOKLYN 1, N. Y.

How one Pittsburgh Brush*

POLISHES 10,000 HEATING UNITS

** An actual case history from The Edwin L. Wiegand Company, producers of CHROMALOX Heating Units.*

WHEN this company needed a way to take the ragged edges off heating units economically and *fast*, they turned to sturdy, tough Pittsburgh Brushes for the answer. The 6" Pittsburgh steel wire brushes like that shown above polish 10,000 heating units during their life.

LET PITTSBURGH ENGINEERS SOLVE YOUR BRUSH PROBLEMS

Pittsburgh's complete line of brushes of every type, for every purpose, will provide a practical, economical solution of any brush problem you might have. Drop us a line on your company letterhead for a copy of our new booklet that shows, through actual case histories, how Pittsburgh can help cut your brushing operation costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W7, 3221 Frederick Ave., Baltimore 29, Md.

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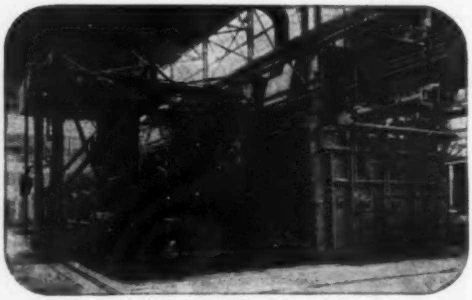
Typical EF Installations

● For the utmost in dependable, efficient, low cost service, specify an EF furnace. Built in roller hearth, roller rail, chain belt, car type, wire belt and many other designs. Complete with special atmosphere generators and material handling facilities. Gas fired, oil fired, or electrically heated for any heating or heat-treating operation—any process—any product—and any capacity requirement. Let the EF engineers, with their long and successful experience in engineering and building furnaces, work with you on your next heat treating job.

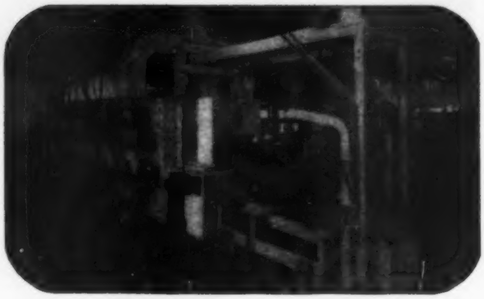
THE ELECTRIC FURNACE CO.

Wilson Street, Salem, Ohio

Gas Fired—Oil Fired and Electric Furnaces

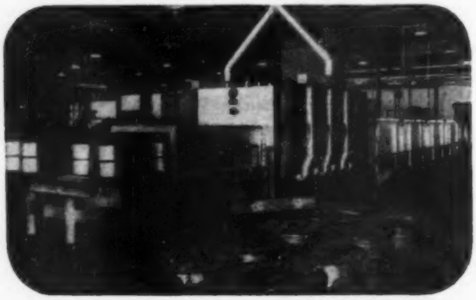


Heavy castings and weldments are heat-treated economically in EF furnaces. Gantry cranes simplify loading, unloading and quenching. Engineered to your particular requirement.



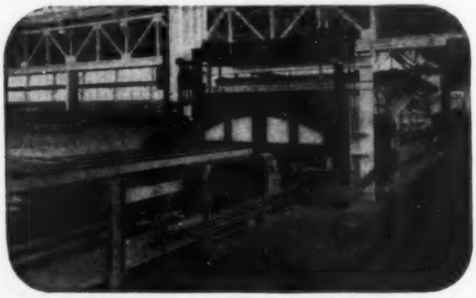
Small parts, headed, drawn, forged or stamped, are heat-treated without scale or decarburization—uniformly and economically—in EF chain belt furnaces. Any capacity.

Continuous annealing of steel strip shortens the heating cycle and improves the drawing qualities. Single or multiple strands to 54" or wider. 28,000 lbs. per hour or more.



Ferrous and non-ferrous wire on reels, spools, coils and strands is bright annealed uniformly and continuously in EF special atmosphere furnaces. Any desired capacity.

Furnace brazing of ferrous and non-ferrous assemblies cuts material, labor and finishing costs; usually eliminates costly dies and insures a stronger, longer lasting, less costly assembly.



Bars and billets are scale-free heated for rolling, drawing or other processing in EF pusher, rotary and other types of special atmosphere furnaces. Any capacity, atmosphere or temperature.

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and many friends and patrons

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A HAPPY AND PROSPEROUS
NEW YEAR

H. H. HARRIS, *President*

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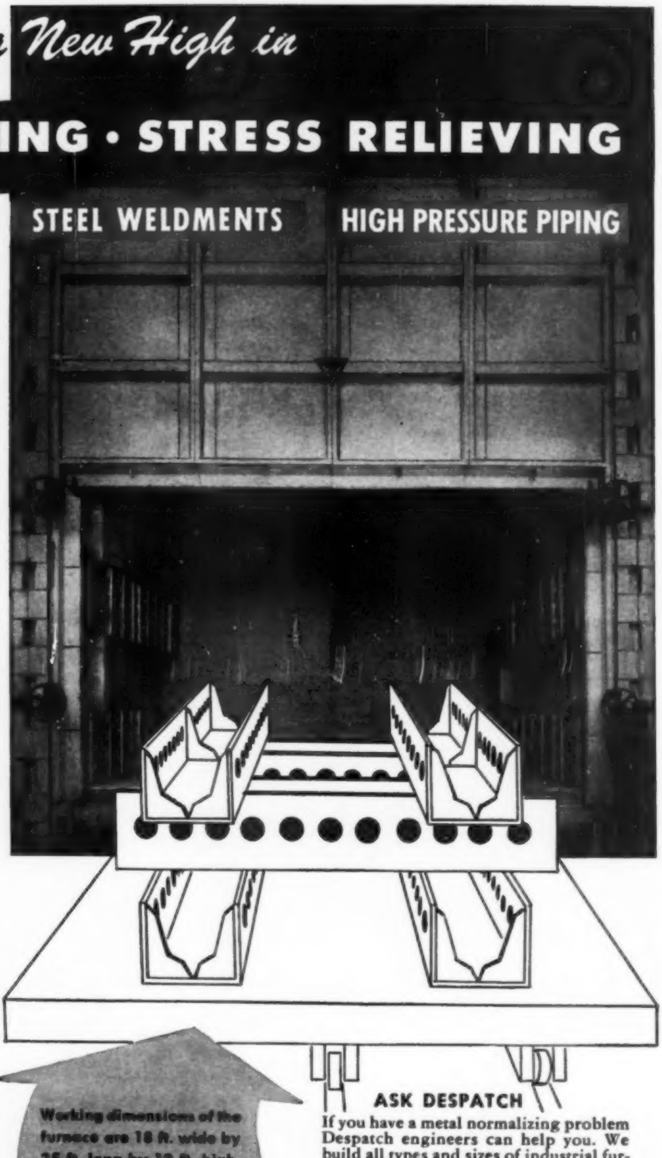
HEAT TREATING • STRESS RELIEVING

ALUMINUM ASSEMBLIES — STEEL WELDMENTS — HIGH PRESSURE PIPING



Recirculating Type Car Bottom

FURNACE

built and installed at Bath Iron Works, Bath, Maine by

DESPATCH

Designed for close temperature cycle control and uniform heat throughout the work chamber, this Despatch built large batch type furnace provides the highest efficiency in solution heat treating and stress relieving of aluminum gun foundations, and stress relieving of steel weldments and high pressure piping. Temperature maximum of the unit is 1350°F. Two 3,000,000 BTU per hour oil heaters furnish ample heat and special high volume fans transfer heat at great velocity throughout the work chamber to achieve the required uniformity. The furnace has automatic temperature controls and approved safety equipment.

LARGE CAPACITY AND CAR BOTTOM TYPE SPEED WORK

The car which forms the furnace floor has special heat sealing edges and is equipped with an electric car pull allowing a maximum speed of 20 ft. per minute. The lift door is also electrically operated.

Capacity for stress relieving steel weldments and high pressure piping is 12,000 lbs.; for aluminum gun foundations, 5,400 lbs. plus 2,000 lbs. of steel jigs and fixtures.

ASK DESPATCH

If you have a metal normalizing problem Despatch engineers can help you. We build all types and sizes of industrial furnaces. Despatch also designs, builds and installs foundry ovens, finish bake ovens or complete finishing systems to fit every production need. Call or write Despatch Today for further details.

DESPATCH OVEN COMPANY

Minneapolis office: 619 S. E. 8th Street
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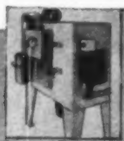


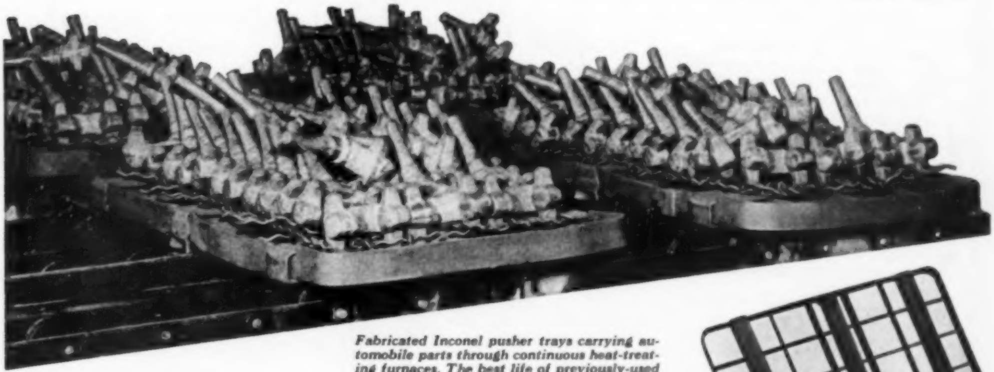
Despatch CF-14 (Batch Type) Electric Heated Furnace.

Despatch gas fired core oven with overhead monorail and carrier loading system.

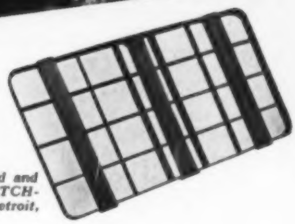
Despatch tunnel-type floor conveyor finish bake oven.

Meet a *LIGHT-WEIGHT* champion..

Inconel pusher trays still going strong on a job that licked heavier furnace trays!



Fabricated Inconel pusher trays carrying automobile parts through continuous heat-treating furnaces. The best life of previously-used trays averaged nine months. The fabricated Inconel trays have been in use over one year.



Inconel pusher tray designed and fabricated by BROWN-HUTCHINSON IRON WORKS, Detroit, Michigan.

- **Furnace production increased**
- **Tray life increased**
- **Maintenance costs reduced**

These substantial benefits are what a large automobile manufacturer gained by switching to fabricated Inconel* pusher furnace trays.

Previously-used trays weighed from 114 to 198 pounds each. The fabricated Inconel trays weigh only 86 pounds . . . a weight saving 28 to 112 lbs. per tray. Based on average net load of 400 pounds this represents a gross weight saving of 5 to 19% over previous equipment.

Even more important—these lighter-weight fabricated Inconel trays last longer, with correspondingly reduced replacement and maintenance costs.

This fine performance record is even more remarkable when the severity of service conditions are considered. During the heat-treating of automobile parts, the trays are subjected to temperatures as high as 1650° F., followed by oil quenching.

The furnaces, which are gas-fired and non-atmosphere in type, present high-temperature corrosion problems. Add to these punishing conditions the considerable mechanical forces acting on the trays . . . up to 540 pounds load plus 2000 pounds thrust from the hydraulic pusher mechanism . . . *and you have service conditions that demand Inconel plus good fixture design.*

Brown-Hutchinson Iron Works are designers and fabricators of these pusher trays. They, like other leading fabricators, used Inconel because of Inconel's outstanding performance record and desirable combination of physical characteristics . . . thermal durability, corrosion-resistance, high hot and cold strength, workability, economy.

Although Nickel and Nickel Alloys are currently in short supply, Inco advertisements will continue to bring you information on industrial processes and developments which we believe will be of interest.

*Reg. U. S. Pat. Off.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

INCONEL* ...for long life at high temperatures

TIPS ON MACHINING Stainless Steel for Higher Production AT LOWER COST

DATA!

Page B-3

AUSTENITIC STAINLESS STEELS (Cont.)

Wide Variance in Machinability

Types such as 303 are considered free-machining 18-8 grades, while various other 18-8 grades such as types 321 and 347 are extremely difficult to machine. These latter types are especially serviceable at elevated temperatures and will be found to be used frequently for aircraft parts, particularly jet engine parts where extremely high heat may be encountered, and high strength is essential.

Cutting Fluids for Austenitic Stainless Steels

For the machining of all grades of stainless steel the presence of active or effective sulphur in the cutting fluid in varying amounts is vitally important as this quality tends to reduce the work-hardening characteristics and tendency of these materials to pick-up and weld to tool surfaces.

It should be pointed out that the severity of the machine operation has a direct bearing on cutting fluid application. Operations such as tapping, threading and broaching where slower speeds and heavier cuts are usually in evidence, require a cutting fluid high in active sulphur and factors of lubricity.

Generally speaking, however, the free-machining grades of austenitic stainless steel demand a balanced amount of active sulphur while types such as 347 require the maximum possible amount to prevent chip weld and provide smooth finishes.

PROOF!

STUART'S THREDKUT 99 FOR STAINLESS

A Wisconsin manufacturer recently tried twelve different heavy duty cutting fluids for the tapping of type 310 stainless steel. One of the oils that failed sold for 45c per pound. Production with the best of these products amounted to 50 holes per tap. With Stuart's THREDKUT 99, production was increased to 550 holes per tap.

D.A. Stuart Oil CO.

2743 S. Troy Street, Chicago 23, Illinois

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- TEMPERING
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$2 each — gives up to 2000 readings

Available in these temperatures (°F)

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125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

FREE —Tempil° "Basic Guide to Ferrous Metallurgy" — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

GORDON SERVICE

CLAUD S. GORDON CO.

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Know-how

based on 45 years' experience, including pioneering of the first successful furnace atmosphere control.

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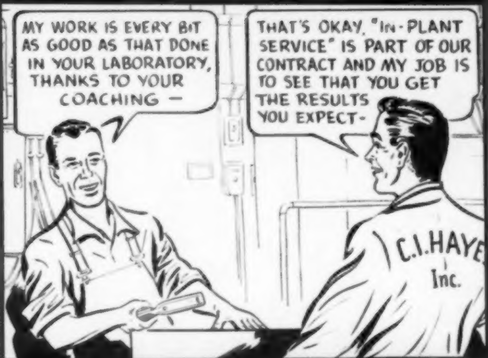
We put our know-how to work on YOUR samples in our laboratory on production equipment. The satisfactory results we get here, we guarantee to reproduce in your plant.

IN YOUR PLANT



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Our know-how is imparted to your heat-treating staff, so they can surely and positively produce the quality and quantity of work you expect.

You're SURE of satisfactory operation.

For the BEST in controlled-atmosphere equipment

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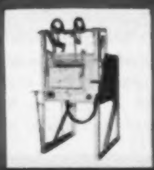
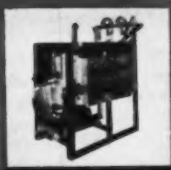

TOOL HARDENING


AMMONIA DISSOCIATOR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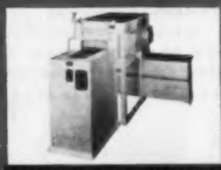
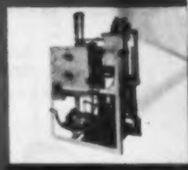

CARBO-NITRIDING — HARDENING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Manufacturers of Electric Furnaces Since 1905

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COOLEY ELECTRIC MFG. CORP.
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There's nothing static about Spincraft spinning and fabricating. It gives you a most flexible approach to design and production — whether quantities are large or small. Best of all, Spincraft methods eliminate high tooling costs; gain weeks of time; save many, many dollars.

The scope of these abilities and facilities in all metals is highlighted in a new reference book that points the way to far greater economy in the production of many parts or products. Here is a source of practical how-to-do-it ideas plus solid engineering facts that is yours for the asking. Send for your copy of the Spincraft data book, now.

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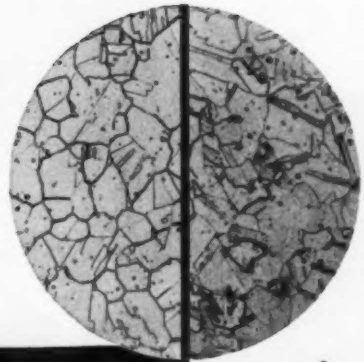
Heretofore known as Milwaukee Metal Spinning Co.

Cathodically etched in helium at 60 microns Hg and 4000 volts, this Type 303 stainless steel (X250, left) shows a well-defined grain structure quite different from—a conventional acid etch of the same specimen (X250, right). The structure uncovered by cathodic etching and the ease of preparing specimens by this method are big metallurgical news.



for the metallurgist... a new weapon

CATHODIC ETCHING, it's called. It's a new way of preparing specimens for metallography, using ionic bombardment in vacuum, instead of chemical etchants. It points up some metallurgical facts that have been difficult to get at till now.

For example, take the case of a sticking contact point for the generator cutout in one of America's leading cars. Photomicrographs of a cathodically etched sample showed cold flow lines.

But why cold flow lines in a hot-forged part? That question cracked the case. Such lines are rarely shown by chemical etching, but cathodic etching picked them right up.

It turned out that the subcontractor wasn't hot-forging them at all, but cold-working them. As soon as that misunderstanding was cleared up, the contacts stopped sticking.

For effective industrial sleuthing and profitable scientific puzzle-solving, you need such new viewpoints. The surface structure thus uncovered may well shed meaningful new light not only in metallography but also in electron micrography and electron diffraction studies.

If you're a metallurgist and like to keep up to date, you'll do well to write for further information from ***Distillation Products Industries,*** Vacuum Equipment Department, 753 Ridge Road West, Rochester 3, N. Y. (Division of Eastman Kodak Company).

high vacuum research and engineering

DPi

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NEW BROWN *Fast-Speed Thermocouple* IS FASTER BECAUSE:

(1) Butt-welding replaces mass of metal at hot junction; (2) Shape of wire adjacent to junction holds back insulator, prevents it from dissipating heat and affecting response of the thermocouple.

Depending upon the application, this *Fast-Speed Thermocouple* is $1\frac{1}{3}$ to 9 times faster than conventional type thermocouples.

In the picture you see Denny Somers, Honeywell Supplies Man of our Philadelphia office, telling a customer all about the new Brown *Fast-Speed Thermocouple* . . . after describing all of the benefits of the HSM Plan for buying pyrometer supplies.

You'll be pleasantly surprised when *you learn* how *the plan* can add convenience and economy to your pyrometer supplies purchasing, too!

There's a Honeywell Supplies Man near you . . . at your local Honeywell office . . . no further away than your phone. Call him in today, and you'll take an easy step in the right direction!

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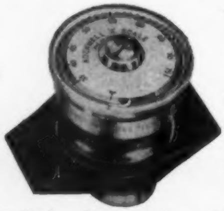
The *ERNST* Portable HARDNESS TESTER

Quick . . . Accurate, Direct Readings



1. **Size and Portability.** Over-all size, Height 3", Diameter $2\frac{1}{2}$", Packed in case 6" x $3\frac{3}{4}$" x $3\frac{1}{2}$". Weight net 30 oz.
2. **Accuracy.** Each Instrument individually calibrated.
3. **Operation.** By Hand Pressure.
4. **Indentation.** Maximum depth 0.003", Maximum diameter 0.006".
5. **Scale.** Direct readings of hardness on visible scale to either Rockwell or Brinell — low, medium or high ranges.
6. **Penetration.** "Static" and not determined by "Shock" application.

The instrument is designed to meet long demand for reasonably priced, portable, accurate product giving direct readings without reference to conversion scales or calculations.

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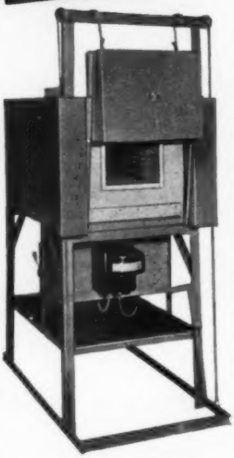

The sturdy, production-type Huppert Furnace not only attains highest-level efficiency, but cuts operating costs to a minimum through unique Huppert method of multi-insulation surrounding all sides of the work chamber. This furnace provides a versatile heat range — continuous up to 1850°F., intermittent to 1950°F. Also built for 2300°F. for special applications.

Automatic Temperature Control featured. Also tight-seating, wedge-type door and convenient shelf.

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Model No. 16 illustrated, 12" x 8" x 18" — $925.00 complete.

K. H. HUPPERT COMPANY

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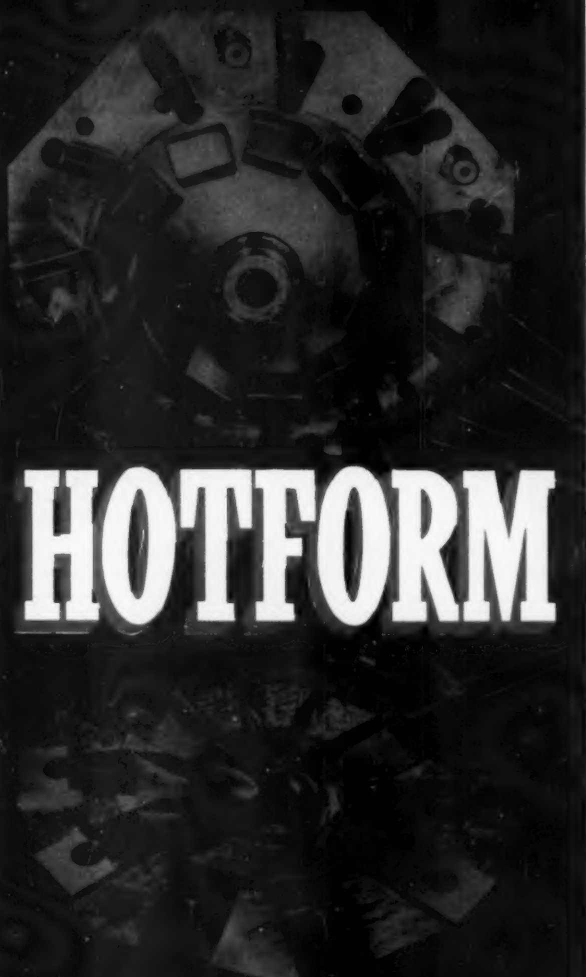
◄ ***Manufacturers of Electric Furnaces & Ovens*** ►



HOTFORM is also available in drill rod and centerless ground sizes for ejector pins and cores.

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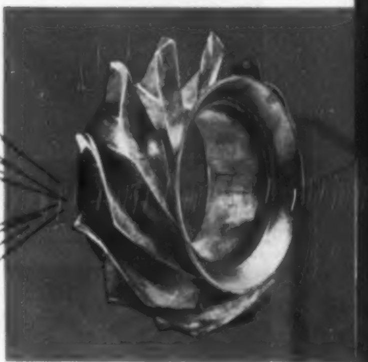
for performance

in a great new automotive drive!



These beautiful impeller die casting dies for an outstanding automatic transmission are made of HOTFORM—because HOTFORM assures maximum die life and can be relied upon not to crack or show movement in heat treating, even in large and complex shapes. In this exacting application, die movement is stated to have been held within .002″. ● Your next tough application merits HOTFORM. Let us discuss it with you!

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Vanadium-Alloys

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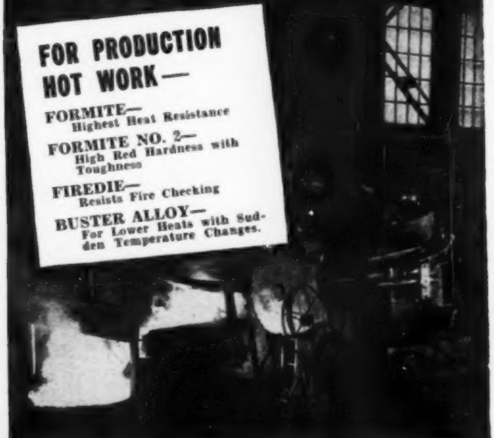

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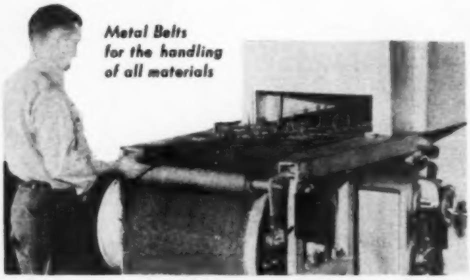
Correct Furnace Belt selection assures longer life, greater efficiency. Ashworth engineers have the ability to recommend the right type of belt for service of a cyclic nature, from room temperature to 2050° Fahrenheit.

Metal Belts for the handling of all materials



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resist HEAT, CORROSION, GASES, ACIDS

In a wide range of chemical and industrial applications, PYRASTEEL parts furnish an extra margin of protection that insures long service life and maintenance economy.

PYRASTEEL is a specially developed, electric-furnace, chrome-nickel alloy that provides sustained resistance to temperatures up to 2000° F. It is also highly resistant to corrosive gases and most concentrated or dilute commercial acids.

PYRASTEEL is useful in thousands of tough jobs, such as chemical manufacturing, food processing equipment, furnace parts, conveyor screws, refinery valves and fittings, for increased service life.

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Makers of Alloy Steel for Over 40 Years

Announcing THE NEW AB SPEED PRESS

This Streamlined AB SPEED PRESS

offers the metallurgist a new tool with the unparalleled qualities of precision workmanship, speed and convenience in the preparation of metallurgical specimens into plastic mounts.

The new AB SPEED PRESS produces perfect Bakelite mounts in 2½ to 3½ minutes and may be used with 1", 1¼" or 1½" molds.

Our introduction of preheated Premolds has revolutionized the preparation of metallurgical specimens.

The Premolds are dust-free, increase the convenience in handling, and are available at little extra cost. The Preheat Compartment reduces the curing time of thermoset molds to one-third of the time. The operation is controlled by Pyrometer, Timer and Thermostats.

These features in the new AB SPEED PRESS are destined to set a new mark in the development of metallurgical specimen preparation. It provides all metallurgists with the most advanced press equipment for speed, convenience, and economy never known before.

No. 1330 AB SPEED PRESS, complete with 1" mold assembly, thermostat controlled heater for 110 volts A.C., 600-watt, cooler blocks; 10,000-lb. capacity hydraulic jack; pressure gauge, pyrometer, timer clock, and pilot lights; premold assembly with heating compartment and ejector levers. With directions. **$380.00**

No. 1330-2 AB SPEED PRESS complete, same as No. 1330, except for 1¼" mountings. With directions. **$400.00**

No. 1330-3 AB SPEED PRESS complete, same as No. 1330, except for 1½" mountings. With directions. **$430.00**

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

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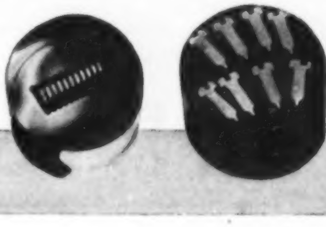
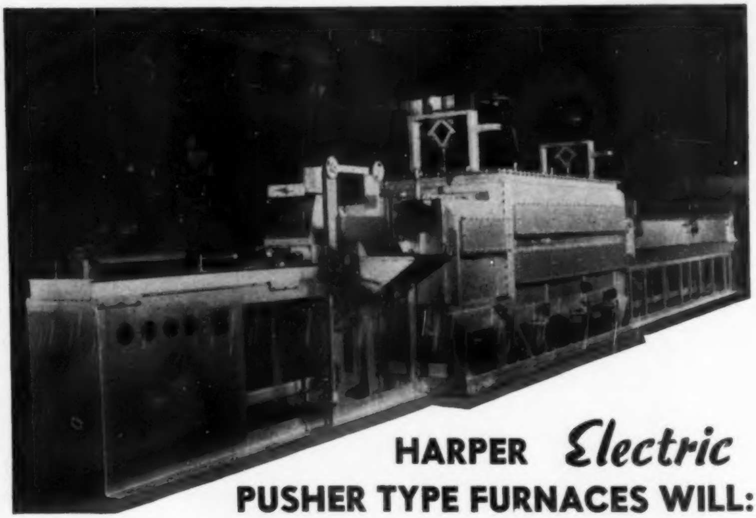


METALLURGICAL APPARATUS
165 West Wacker Drive, Chicago 1, Illinois

LOADS UP TO 50 LBS. PER SQUARE FOOT SINTERED AND BRAZED AT 2100°F IN

Harper *Electric* Pusher Type Furnaces



Harper Electric Pusher Type Furnace Model HOU - 184110 - HH - 21, 47 feet long, for sintering and brazing operations up to 2100° F.

HARPER *Electric* PUSHER TYPE FURNACES WILL:

HANDLE DENSER LOADS

Sintering and brazing of dense loads is now being done in Harper Pusher Type Furnaces, like the furnace pictured above. Loads up to 50# per square foot can be loaded on trays and pushed through the furnace chamber on rigidly-constructed ceramic or metallic hearths which are capable of withstanding extreme pressures without distortion.

GIVE HIGHER PRODUCTION

These furnaces give higher production of properly heat-treated parts, resulting in low man hours per pound of charge. They have a longer chamber enabling more charge to be pusher faster through the furnace. Globar Heating Elements permit more power to be applied for faster firing.

LOWER YOUR OPERATING COSTS

You will realize lower operating costs with a Harper Electric Pusher Type Furnace. These furnaces are designed for automatic operation, thus requiring less attendants. They reduce the cost of the more expensive method of conveying materials through the furnace.

Let us show you how a Harper Electric Pusher Type Furnace can give you greater production and save you money in your sintering and brazing operations. Write to Dept. #7 today and we will gladly send you full details, or, if you have a specific application, a Harper Engineer will call.

HARPER ELECTRIC FURNACE CORPORATION

39 RIVER ST. **BUFFALO 2, NEW YORK**

Representatives in Principal Cities

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ammunition shells, cartridge clips, shoe eyelets, buckles, buttons, harness hardware, radar parts, used in World War II, received these government-approved, protective black finishes. Enthone Ebonol blackening processes meet today's Army, Navy and Air Force specifications for black oxide coatings on steel, copper, brass and zinc . . . for wear, reflectivity, saltspray, and weathering. NEW EBONOL Booklet *including detailed operating instructions, sent free on request. U.S. Patents*—2,364,993, 2,460,896, 2,460,898, 2,481,854. Canada, 463,852.

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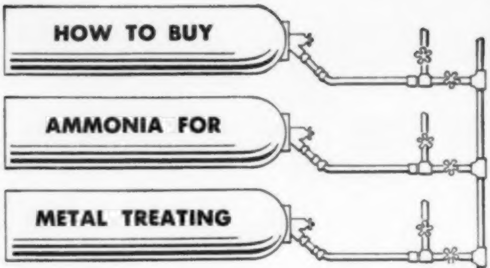

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Quality ammonia is, of course, extremely important in metal-treating processes. But even more important is its efficient and economical application to your particular process.

For many years, Armour's Technical Service Department has specialized in the metal-treating uses of ammonia. Their broad experience enables them to assist you in determining the best application of ammonia to your heat-treating problems . . . whether you are *nitriding*, *carbonitriding* or using *dissociated ammonia*. In addition to practical experience gained from helping many manufacturers, Armour has sponsored research for several years in one of the country's leading technical institutions to investigate the carbonitriding process.

Make Armour your headquarters for information on the metal-treating applications of ammonia. Free literature containing useful and valuable information is yours for the asking. *Write today* for your copy of one or all of the booklets listed in the coupon below.

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Please send booklets I have checked

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- ☐ Effective Use of Dissociated Ammonia
- ☐ The Carbonitriding of Steel
- ☐ The Nitriding Process

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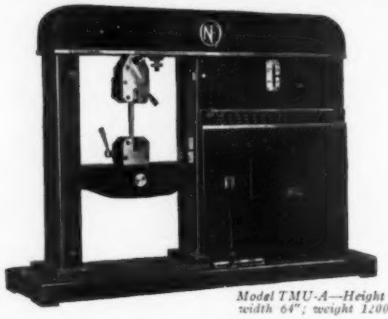
It Will Pay to Make Your Own Tests with

NATIONAL FORGE
UNIVERSAL TESTING UNITS



Model TMU-A—Height 44"; width 64"; weight 1200 lbs.

The National Forge Universal Testing Machine, Model TMU, is compact, accurate, dependable, easy to operate and moderately-priced.

Wide working clearances, long stroke, quick-action simplified variable-speed control, improved grips and a wide spread of load scale ranges adapt this modern, streamlined unit to production, research or school instruction tests of a great variety of materials and specimen sizes. A.S.T.M. accuracy requirements are guaranteed.

Three load ranges: Model TMU-A -0-30,000, 0-6000, 0-600 lbs. Model TMU-B - 0-15,000, 0-3000, 0-300 lbs.

For details, write for Brochure 501.

TESTING MACHINE DIVISION

NATIONAL FORGE & ORDNANCE CO.

Dept. MP **IRVINE, WARREN COUNTY, PENNA.**

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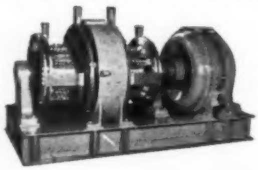
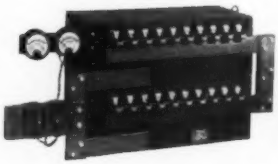


- **TANK RHEOSTATS**
- **REVERSING SWITCHES**
- **TONG TEST AMMETERS**



Write for Descriptive Bulletins

COLUMBIA ELECTRIC MFG. CO.

4531 Hamilton Ave. • Cleveland 14, Ohio

Tests show New Quench Oil has Intensified Triple Action

A new accelerated quenching oil has been developed that gives (1) rapid heat removal with faster cooling rate in the hardening range, this results in higher and deeper hardness; (2) slow cooling below the hardening range, thus minimizing distortion; (3) greater stability due to special anti-oxidants, for longer life and bright quenching properties.

To better illustrate the manner in which this triple action quenching oil accomplishes this higher quenching efficiency, it will be well to show the three stages of cooling as observed when steel is quenched in oil from a red heat. These stages are:

A. Formation of a vapor film at the steel surface; cooling is accomplished by conduction and radiation through this vapor film and is relatively slow.

B. Direct contact of the oil with the metal surfaces, causing a boiling action which continually dissipates the vapor film formed and results in rapid cooling.

C. After the metal has been cooled to the boiling point of oil, vapor is no longer formed; cooling is by conduction and convection, and the metal slowly cools to the temperature of the oil.

It is apparent that any improvement in the cooling power of oil in stages A and B would be most desirable. This can be compared to the brine quench which is used instead of water. Brine has a wetting action that completes the quench faster than fresh water, which "takes hold" only in spots, causing non-uniformity. Salt brine solutions provide deeper and more uniform hardnesses. This results in deeper and more even hardnesses. It seems logical to attempt to do this same thing with oil. The mineral intensifiers added to this Triple A Quenching Oil act in this manner.

Practical Application of Quench Curves to Hardening Steel

The improvement of oils so as to effect this desired change in the cooling characteristics has been attempted in the past by blending mineral oil with animal oils, but the product was prone to become rancid, or to decompose on contact with hot steel. These blends were also unsatisfactory as quenching mediums for steel treated in certain types of salt baths.

Developed in the Research Laboratory of the Park Chemical Co., the Park Triple A Quench Oil, a blend of specially refined mineral oils, cools steel faster in the upper temperature range by shortening the duration of vapor stage (A) and intensifying the action of boiling stage (B). Heat removal in stage (C) is slow and uniform. Thus, the best surface hardness and depth of hardness penetration are achieved with no danger of cracking or distortion.

Extremely stable, this new accelerated quenching oil may be used as a quench from any heat treating medium without fear of rancidity, oil breakdown, or change in quenching efficiency. Further, Park Triple A Oil is especially suitable for obtaining the maximum uniform oil-quenched hardenability from low and medium alloy steels.

Results of the improvement are shown in chart below showing actual hardnesses in quenched pieces. There is a 16% surface hardness increase with Park Triple A Oil over a good grade of straight mineral oil. The effect would be greater when comparing it with some of the poorer grades of oil used for quenching. Center hardnesses of the one-inch diameter piece are up 14%. Lighter sections would show even more increases.

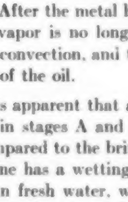
Bright Quenching and Stability

A very crucial and costly problem in the carbo-nitriding process has been the cleanliness of work after oil quenching. Oils which deteriorate rapidly or were originally unsuitable leave a sooty carbonaceous film on the surface of the work. This presents a difficult cleaning problem when followed by a plating or welding operation.

This difficulty, when not the fault of the furnace atmosphere, can be corrected by the use of Park Triple A Quench Oil.

Through the use of anti-oxidant additives and mineral intensifier it has been possible to prolong the bright quenching properties of good clean oil. Underwood Oxidation experiments have proven Park Triple A Quench Oil to have exceptional stability and long life.

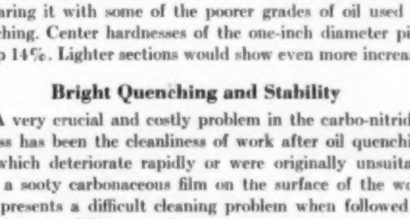
A Bulletin, #F8, was prepared on Park's Triple A Quench Oil. It gives you a complete description of this oil with cooling curves, production data and photographs. Write Park Chemical Co., 8074 Military Ave., Detroit 4, Mich.



STEEL: S.A.E. 1045 1" ϕ x 2"

TREATMENT: 1550° F. IN NEUTRAL SALT QUENCH IN OIL AT 75° F.

HARDNESS: ROCKWELL "C" READINGS ACROSS INNER SURFACES OF SECTIONED SAMPLES



Transverse hardness Rc taken on 1" round SAE 1045 steel two inches long. Quench from Park's Nu-Sal neutral salt at 1550°F. into three types of quench oil, Park's No. 100 Oil (straight paraffin), Park's "S" Oil (compound with animal oil), Park's Triple A Oil. Oil temperatures 75° F.

• Index to Advertisers •

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3030 Euclid Avenue, CLEVELAND, OHIO.

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PRESSURE VESSEL ACCESSORIES

TYPE "R" MANWAY

TYPE "R" NOZZLE WITH COVER

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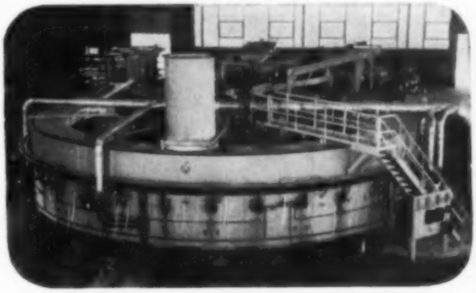
your requirements
best!

Because we build all types of batch and continuous furnaces—in sizes to meet any production requirement—gas-fired, oil-fired, and electrically heated—we can recommend *without prejudice* the type—the size—and the method of heating—that suits all phases of *your particular* problem best.

On your next annealing, brazing, hardening, solution treating, carbon restoration, carburizing or other heating or heat treating problem—investigate EF developments—available only in EF furnaces. We solicit your inquiries.

Gas-fired EF radiant tube continuous pusher-type furnace used for gas carburizing and other heat treating processes requiring several widely different cycles.



Oil-fired EF rotary furnace equipped with automatically controlled hydraulically operated charging and discharge mechanism —heats 35,000 lbs. of large billets per hour.

Electrically heated EF wire mesh belt conveyor furnace . . . for brazing, annealing, sintering, and other heat treating of aluminum, brass, copper and steel products.

Gas-Fired, Oil-Fired **EF** ***and Electric Furnaces***
for any Process, Product or Production
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